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CONSTRUCTIVE METHODS IN GEOMETRY

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The purpose of this paper is to emphasize the importance of the constructive side of geometric instruction in elementary as well as advanced courses, and also if possible, in mathematical research work.

Most of the geometrical teaching, with a few commendable exceptions, is conspicuously deficient in this respect. The neglect of the constructive phase of geometry is, in most cases, not intended by the teacher; it is primarily due to his deficient training on constructive methods.

It is, of course, impossible to give an exhaustive account of an advisable course of procedure in geometric instruction and work within the short available time. So I shall content myself to show by some typical examples what I understand by effective and interesting treatment of geometrical problems.

The principle of linear one-to-one correspondence can easily be introduced in an elementary course in solid geometry. Consider a pyramid with a vertex O and base $ABCDE\cdots$ in plane p, Fig. 1. Let another plane p' cut p in s, and the edges of the pyramid in $A'B'C'D'E'\cdots$. Then it is at once evident that:

(1) the joins of corresponding points A and A' pass through O;

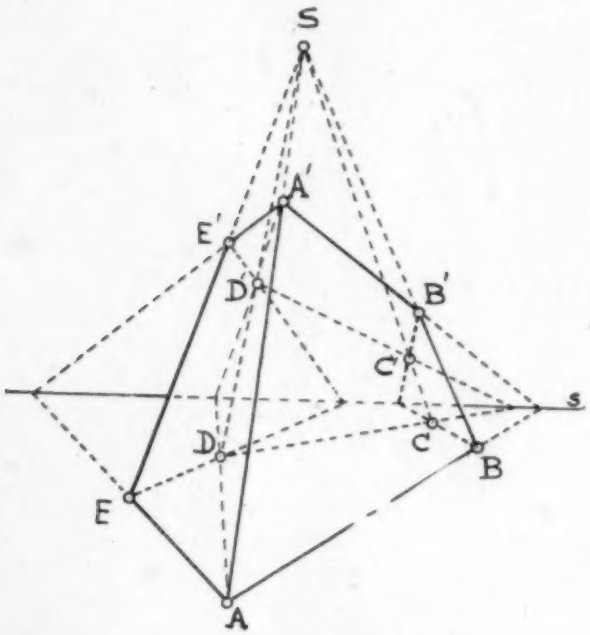
(2) the intersections of corresponding lines like AB and $A'B'$, AD and $A'D'$, Be and $B'e'$, etc., lie on s.

In this manner there arises a linear (1—1) correspondence between the points and lines of the planes p and p', which is entirely controlled by the foregoing principles (1) and (2). Clearly, when O, s, and a pair of corresponding points A, A' (or lines l, l') are given, the correspondence is absolutely determined. Thus we here hit most directly upon the fundamental principles of perspective, a particular case of collineation in general. It

is not difficult after this stage to introduce the essentials of general collineation, or projective transformation, and the idea of the continuous group.

As another instructive example I shall choose the hyperboloid of rotation of one sheet. In solid analytic geometry the study of this surface usually consists in the discussion of the plane sections parallel to the coordinate planes (including these). Very little attention is paid to the geometric organism of the surface, for instance its cinematic properties.

As is well known this surface is generated by a line (generator) rotating about a fixed skew axis, relatively unchanged in its relation to this axis. Let a and g be axis and generator, and



OM the common perpendicular between a and g, respectively. Choose O as the origin of a Cartesian system, and a as the z-axis, Fig. 2. The projection g' of g upon the xy-plane is perpendicular to OM. When g rotates about a, every point P of g describes a circle with center on a and its plane perpendicular to a. Clearly M describes the smallest of these circles, which lies in the xy-plane, and has the equation $x^2+y^2=r^2$, if $OM=r$. To derive the equation of the surface generated by g, denote the coordinates of any point P on g by x,y,z, and let $P'(x,y)$ be

the projection of P upon the xy-plane. Then $OP'^2 = x^2 + y^2$. Let $\angle PMP' = \theta$ be the constant angle between g and g', so that, from Fig. 2, $OQ = x$, $QP' = y$, $P'P = z$, $\angle MP'N = \angle MOS = \phi$, $\angle PMP' = \theta = \text{constant}$. Now

$$OQ = OS - QS = OS - NM = r\cos\phi - MP'\sin\phi,$$
$$QP' = QN + NP' = SM + NP' = r\sin\phi + MP'\cos\phi,$$

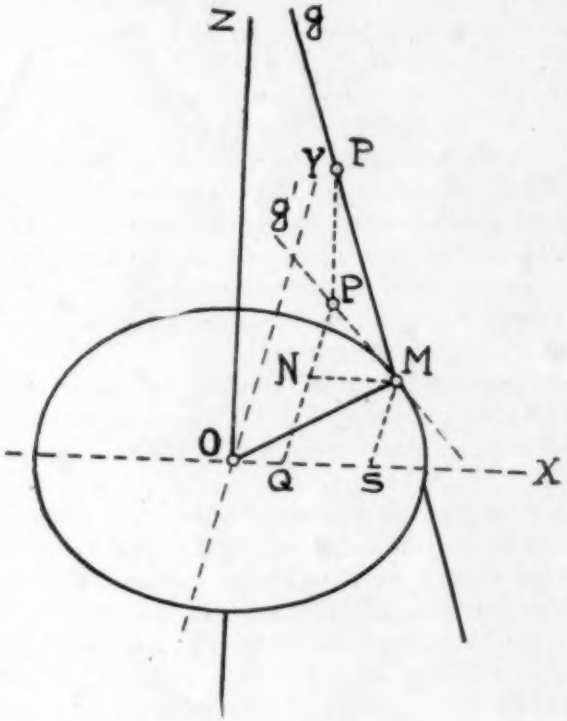
or

$$x = r\cos\phi - z\cot\theta \cdot \sin\phi,$$
$$y = r\sin\phi + z\cot\theta \cdot \cos\phi.$$

Squaring, and adding

$$x^2 + y^2 - z^2 \cdot \cot\theta = r^2.$$

This is the required equation.



As $\cot^2\theta = \cot^2(180 - \theta)$ it is evident that the same surface is also generated by a generator g^1 through M in the same vertical plane to the xy-plane with g, and symmetric to g with respect to the plane through a and M.

Thus are revealed at once the two systems of generators on

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[1]William Farish was the first to point out the practical value of this method in an article on isometric projection in the *Transactions of the Cambridge Philosophical Society*, Vol. I, pp. 1-19 (1820).

the hyperboloid of rotation of one sheet by cinematics. But it is not difficult to show that this is a general property of quadrics. The equation of the general hyperboloid of one sheet may be written in the form

$$a^2x^2+b^2y^2-c^2z^2-d^2 = 0,$$

or $$(ax+cz)\,(ax-cz)+(by+d)(by-d) = 0.$$

This equation may be considered as the result of the elimination of λ between

(4) $$ax+cz-\lambda(by+d) = 0,$$
$$by-d+\lambda(ax-cz) = 0.$$

For every value of λ (4) represents two planes which intersect in a generator of (3). Thus an infinite system of generators is established. But (3) is also the result of the elimination between

(5) $$ax+cz-\lambda(by-d) = 0,$$
$$by+d+\lambda(ax-cz) = 0,$$

which establishes the existence of a second system of generators on the surface. Moreover, a closer inspection of the systems of equations (4) and (5) shows that no two generators of the same system intersect; but that every generator of one system intersects every generator of the second system.

This procedure applies to all proper quadrics, if we admit systems of imaginary generators.

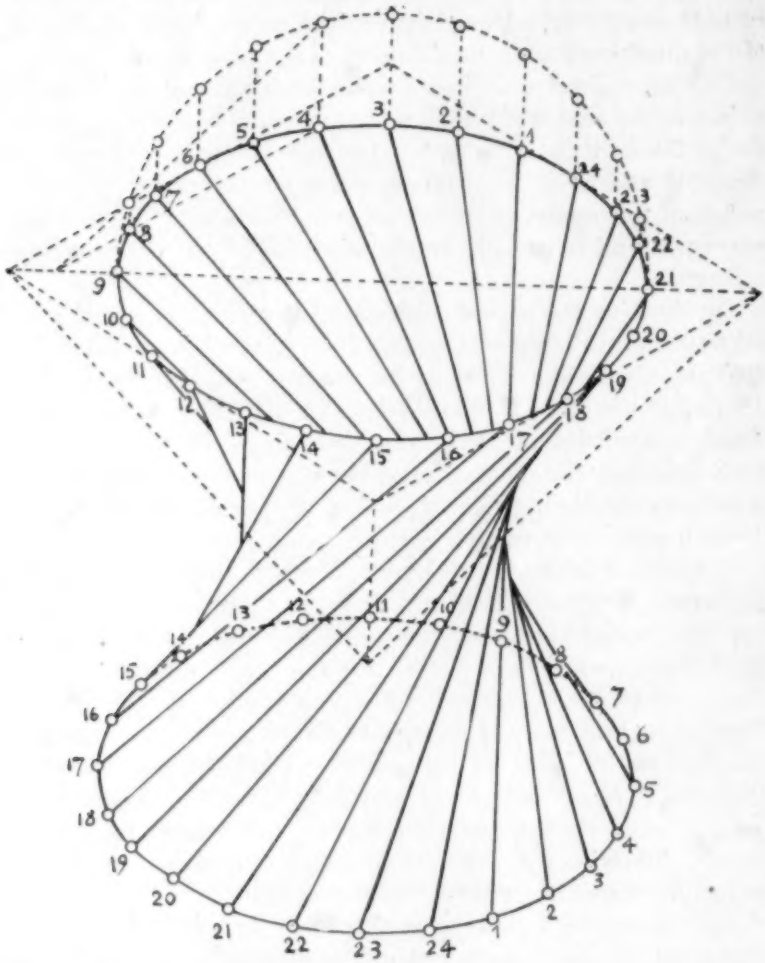
The next important step in the study of our hyperboloid is a proper graphic representation. There are various methods for this purpose. I shall choose a very effective isometric projection.

By this is understood the usual orientation of figures with respect to three coordinate planes OXY, OYZ, OZX. For the plane of projection p we then choose a plane equally inclined towards the three axes OX, OY, OZ. In this manner, after the projection, the projected axes appear as three lines $O'X'$, $O'Y'$, $O'Z'$, so that $\angle X'O'Y' = \angle Y'O'Z' = \angle Z'O'X' = 120°$. The projections of all lines parallel to the coordinate axes are reduced in the *same ratio*, hence the word isometric.

Let the hyperboloid be cut in two equal circles by two planes equally distant from the xy-plane. To these circles circumscribe squares with sides parallel to the x- and y-axis, and divide both circles into the same number of equal parts, so that equivalent division points lie in lines parallel to the z-axis. Number the division points on both circles, but start with the 1's at non-vertically equivalent points. Then join points which have

equal numbers. This line will belong to one of the sets. The second set is readily obtained as shown in Fig. 3.

The drawing is based upon the fact that the circumscribed squares are isometrically projected into rhombs with angles equal 60° and 120°, and that between the original circle and circumscribed square and the isometric projection, ellipse and



circumscribed rhomb, there exists a (1-1) correspondence known as homographic affinity. The application of this principle appears from the figure.

But even in the study of more advanced geometrical theories it is often of value for the understanding and comprehension

of the problem to pay particular attention to constructive possibilities. To illustrate this I shall consider the constructive theory of involutory quadratic Cremona transformations.

Such a transformation can be defined by making use of the proposition that the polars of a point P with respect to a pencil of conics are concurrent at a pointP'. Conversely the polars of P' are concurrent at P. This establishes an involutory quadratic (1-1) correspondence between the points P of the plane Σ of the quadrangle and the points P' of the superposed plane Σ'.

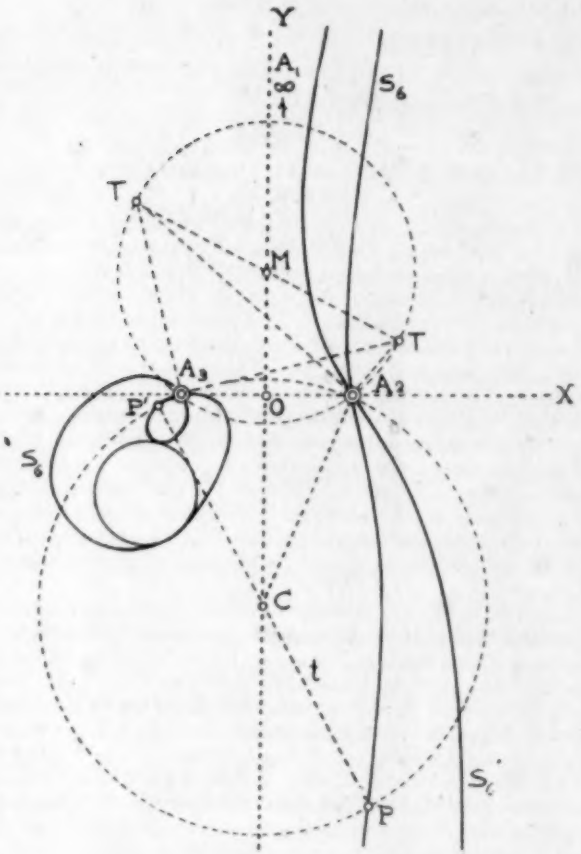
To a line corresponds, in general, a conic through the diagonal points of the base quadrangle of the pencil of conics; i. e., to the net of lines of Σ corresponds the net of conics through the diagonal points in Σ'. These diagonal points are the base points of the quadratic transformation. To each of these points correspond all points of the opposite side of the base diagonal triangle.

By choosing the base quadrangle of the pencil of conics properly, a number of special quadratic involutory transformations may be obtained. Thus, if we choose the points $B_1(1,0)$; $(B_2(-1,0)$; $B_3(0.i)$; $B_4(0,-i)$, $(i = \sqrt{-1})$, the pencil of conics consists of equilateral hyperbolas through B_1, B_2, B_3, B_4, and the corresponding transformation expressed in a superposed complex plane is the inversion $z' = \frac{1}{z}$. All these cases may easily be followed up constructively.

I shall carry this out for the case in which the base quadrangle is formed by $B_1(0,i)$, $B_2(0,-i)$, $B_3 = I$, $B_4 = J$, where I and J are the circular points at infinity. The pencil of conics through these points consists of circles through the intersections of the zero circles $(x-1^2)+y^2 = 0$ and $(x+1)^2+y^2 = 0$. To find the base triangle $A_1A_2A_3$ of the transformation, we have at once as A_1 the infinite point of the y-axis. A_2 in the intersection of B_1J and B_2I, A_3 that of B_1I and B_2J. The equation of B_1J is $y-i = -ix$, that of B_2I $y+i = +ix$, hence their intersection (1,0). Likewise B_1I and B_2J intersect at $(-1,)0$. A_2 and A_3 coincide, therefore, with the centers of the zero-circles C_1 and C_{-1}. From this follows that all circles through A_2 and A_3 are invariant in the transformation. To construct P' when any point P is given, connect P to A_2 and A_3; draw perpendiculars p_2 and p_3 at A_2 and A_3 to PA_2 and PA_3. Then p_2 and p_3, the polars of T with respect to C_1 and C_{-1}, intersect at P'. Obviously, P, P' and A_2 and A_3 lie on a circle, with PP' as a diameter; hence this diameter is bisected by the y-axis at M, Fig. 4. On

every line l there are, in general, two corresponding points P and P'. To construct these, connect the point of intersection C of l and the y-axis with A_2 (or A_3), then the circle with C as a center and CA_2 as a radius cuts t in P and P'. The analytic form of the transformation is easily found as

$$x' = -x$$
$$y' = \frac{x^2-1}{y}$$



An interesting problem in the theory of quadratic transformations (as a matter of fact of general Cremona transformations) is the establishment of invariant algebraic curves. A paper on this problem will soon appear in the *Tohokn Mathematical Journal*. All curves of this kind are obtained as loci of pairs of corresponding points on the tangents of an algebraic curve Γn.

In case of a conic Γ_2 in a general position this locus is an invariant sextic S_6 with seven double points (i. e. of genus 3) at the A's and B's. In case when Γ_2 is a circle, the sextic is bicircular and has three real double points, A_1 (infinite point of y-axis), A_2, and A_3. The construction of this sextic is extremely simple, as shown in Fig. 4. Any tangent t of the circle Γ_2 cuts the y-axis in a point C. With C as a center and CA_2 as a radius describe a circle which will cut t in two points P and P' of the sextic S_6.

I might produce examples of this sort in great number, which would add further strength to the contention that constructive methods in geometry are of great heuristic value, whose importance should not be underestimated.

GLUCOSE RECOMMENDED AS AUTO RADIATOR ANTI-FREEZE CHEMICAL

Glucose is recommended as a preventive of automobile radiator freezing by Dr. Charles H. LaWall, Department of Theoretical Pharmacy, Philadelphia College of Pharmacy and Science. "For four winters past I have successfully employed commercial glucose with unquestioned efficacy and with no detrimental results whatever," explained Dr. LeWall.

He believes that glucose is superior to anti-freezing mixtures containing denatured or wood alcohol, glycerine, or some chemical salt such as calcium chloride. The ordinary confectioners' white glucose is preferred, although on one occasion he used the glucose sold for table use.

The amount necessary is between 15 and 20 percent or about a pint and a half of glucose to a gallon of water. The glucose may be mixed with enough warm water to completely dissolve it and then added to the remainder of the water in the radiator. No further addition or attention is necessary except to replace the water lost by evaporation. When warm weather arrives the radiator should be emptied, rinsed out and filled up with plain water.

"In addition to using the mixture practically for four years with satisfactory results I also performed some experiments to determine the congealing point of such a mixture," said Dr. LaWall. "I found that it begins to get slushy at about 10 degrees above zero Fahrenheit, but that it does not actually freeze and harden even at 6 degrees below zero Fahrenheit.

"Glucose does not corrode nor affect metals; in fact, it prevents such action by virtue of its chemical reducing properties. It seems to have no effect upon rubber in the dilution used; at least, I have never had to replace my rubber hose connections. There are no objections to glucose at all that I have found and its inexpensiveness and the freedom from the annoyance of constantly having to replace a volatile solvent such as alcohol are unquestioned advantages."—[*Science Service.*

The United States Bureau of Education now has for free distribution circulars and leaflets on such subjects as Consolidation of Schools, Transportation of Pupils, Supervision of Rural Schools, Equipment for One-Teacher Schools, System of Agricultural Instruction, Salaries of Teachers in Rural Schools, Distribution of State Funds Affecting Consolidation, Home Economics in Rural Schools, Rural Life and Culture Bibliography, and Teachers' Homes.

AT THE SURFACE OF THINGS

By C. C. Kiplinger

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Our present knowledge of the material universe begins with two fundamental ideas, matter and energy, both of which can only be defined in terms of their properties. Furthermore, matter is apparent to the senses only through its reactions with energy and vice versa, we are cognizant of energy through its action on matter and in no other way can either the phenomena of matter or energy be brought to our attention. For example, the material objects in a lighted room are visible because of the light energy which they reflect to the eyes. Or, if the room be darkened, the presence of such objects can be determined by the observer moving about until he comes forcibly in contact with them, his momentum or energy causing him to sense their existence.

A further illustration is to be found in the visibility of the moon on a clear night when it is above the horizon, owing to the satellite intercepting some of the sunlight traveling through space and reflecting it to the observer. Neither the moon nor the sunlight would be apparent, were either absent. Consequently, in view of a multitude of such relationships, we find matter and energy always happily wedded, one unknown without the other, with divorce a practical impossibility. In fact, a glimpse into the interior of matter indicates that energy is the thing from which matter springs, electricity in the form of minute parcels, electrons, apparently constituting the fundamental building blocks of the atoms. It being beyond the scope of this discussion to consider atomic structure, attention will simply be called to the frequency with which electrical phenomena appear in connection with the several phases of surface action to be discussed in the following statements.

Radiant energy is one of the greatest mysteries of present day science. The true character of light is unknown. The recent work of Dr. Dayton C. Miller, who reports an actual ether drift effect in his optical experiments, if confirmed by future experiments, will give us something tangible concerning the most intangible and illusive concept of modern science. In addition, the principle of relativity suggests that in any system the factor time is an essential in the interpretation of natural phenomena as the concepts matter and energy. Further-

more, it is not impossible that now unknown and equally important factors have been overlooked in our struggle to interpret nature.

Nature in her various moods is not essentially superficial, yet the problems of surface phenomena present some of the most fascinating aspects of everyday science. However, before proceeding, it is necessary to formulate a few definitions. Matter is that which occupies space within the limitations of measurements of our senses. The physicist points out that two atoms can, under certain conditions, occupy the same space, because the atom itself is "mostly hole." We are told that the nucleus and valence electron of the atom of hydrogen occupy only about one ten thousandth of the atomic diameter. Dr. Whitney puts it this way: "Representing the hydrogen nucleus by a pinhead, a baseball at a distance of a half mile would be a fair representative of the distance and size of the electron." Consequently, it is conceivable that two rapidly moving atoms on approaching each other may interpenetrate and even produce atomic disruption. This has been accomplished by Sir E. Rutherford, who has obtained Hydrogen from nitrogen.

Energy is that which does work on matter, producing changes in form, state or even composition. Matter may take any one or more of three forms when subjected to varying conditions of concentration, temperature and pressure, namely solid, liquid or gas. The latter are called phases, if the surfaces separating these forms are sharply defined. For example, ice in contact with liquid water and water vapor comprise a three phase system, because the boundaries between the three states of water are clearly apparent. In the case of a mixture of gases, since gases are miscible in all proportions, we can have but a single phase owing to the absence of boundary surfaces.

Contact is an important essential for chemical reactions. Such contact may be not only that of contiguous surfaces, but also electrical and of the photo-radiation type. From the viewpoint of material surfaces, the solid phase may be in contact with solid, liquid or gaseous phases, constituting socalled two phase systems. The liquid phase in turn can be in contact with a liquid or gas. In the case of a gaseous mixture, which as heretofore stated constitutes a single phase, the properties are additive in character.

An example of a solid phase in contact with another solid phase is found in the well known behavior of gold and lead.

If two smooth surfaces of gold and lead are brought closely together, the two metals diffuse or mix for an appreciable depth beyond the surface of contact, this indicating molecular motion even in the solid state. Such a condition of internal dynamic energy was predicted by the philosophers of old and modern experiments support the hypothesis. However, there is some variance of opinion as to the distances between the atoms and molecules of solids. Dr. T. W. Richards contends that they are closely spaced, also that the atom itself is a compressible structure. The latter view is in complete agreement with present theories of atomic structure, the apparently tenuous nature of the atom admitting the possibility of compression.

The phenomena of adhesion and cohesion come under this first system of contact between solids. Dr. W. D. Bancroft states that it is possible that the broken pieces from a freshly fractured porcelain plate could be made to unite as firmly as before breaking, if the adjacent edges could be brought in contact before they had absorbed air and moisture. He also considers the use of face powder as comprising a special case of the adhesion of a fine powder to a curved surface. It may be added that the "raison detre" of the above rests in supposed attraction, either from the viewpoint of the wearer or that of the scientific observer. Flat polished lead surfaces brought into contact finally unite at ordinary temperatures, a kind of cold welding. Glass cells for optical purposes are made by causing optically flat glass surfaces to unite much below the true melting point of the glass. Protective coatings are applied to metals by methods which induce intimate contact between the adjacent surfaces. In fact, Dr. Langmuir and others believe that the forces of adhesion and cohesion are as truly chemical as physical in character. Atomic attraction is the apparent basis of adhesion and cohesion according to the above view.

Why do we speak of the attraction of the atoms of a solid rather than that of the molecules? The epoch-making work of Bragg and Bragg concerning crystalline structure has pointed out that a crystal is a symmetrical arrangement of atoms. For example, a sodium chloride crystal is made up of sodium atoms surrounded by chlorine atoms, each of the latter in turn being the center of a group of sodium atoms. These experimenters found that crystal surfaces, the ultimate particles of which are about one hundred-millionth of a centimeter apart, would re-

flect and diffract X-rays which have a wave length of one billionth of a centimeter, and give diffraction spectra, a study of which made it possible to interpret the structure and arrangement of the crystal molecules and atoms. This may be illustrated by a simple experiment with two pieces of finely meshed wire gauze. If one piece is placed over the other, dark bands appear on holding them between the eyes and a window. The width of the bands will be found to vary with the distances separating the sheets of gauze. Although the analogy is not exact, the value of such an experiment lies in the concrete picture which it presents of the relation of spacing to certain optical phenomena.

Dr. Irwing Langmuir concludes that any crystal constitutes a single massive molecule and also that a given portion of liquid probably is in itself a molecular unit. Dr. Bancroft facetiously remarks that on the assumption of the preceding the removal of a fish from the sea would involve a chemical reaction, owing to the disturbance of the liquid molecule. Of course this sounds "fishy" as well as facetious and we believe with Dr. Bancroft that such an assumption at present is entirely unnecessary.

Differences of electrical potential appear at the surfaces separating different phases and such are especially in evidence when two unlike metals are brought in contact. The following remarks we owe to Dr. O. W. Richardson, *Science*, LIV, 1396, 286.

"In 1792 Volta wrote: 'The metals can by themselves, and of their own proper virtue, excite and dislodge the electric fluid from its state of rest.'

"When uncharged bodies are placed in contact, the potential energy of the electrons in one will in general be different from those of the electrons in the other. If, as in the case of the metals, the electrons are able to move freely, they will so move until an electric field is set up which equilibrates this difference of potential energy. There will thus be an intrinsic or contact difference of potential between metals which is equivalent to the difference in the values of the electronic potential energy and is approximately equal to the latter difference divided by the electronic charge." Also, it has been known for a long time that any two unlike substances, an orange and a piece of wood for example, when brought in contact show potential differences (Ganot's *Physics*, 17 ed., 757). A further study of thermionic emission may aid in furnishing an adequate explanation for the phenomenon of contact electricity.

In the system comprising a solid phase in contact with a liquid phase we have important phenomena presented by syspensoids, gels, absorption, electroendosmosis, and cataphoresis.

A suspensoid is the first example offered of a true colloidal solution, consisting of finely-divided solid particles in suspension in a solvent, ranging from one thousandth of a centimeter to one ten millionth of a centimeter in diameter. It should be noted here that some are inclined to look on the colloidal state as a fourth state of matter. This view does not seem logical to the writer, since the colloidal state finds its genesis in surface conditions produced by the contact of at least two different kinds or states of matter. The smaller of the suspensoid particles do not settle out even on standing for months and if examined by the ultramicroscope, are found to be in constant motion, the well-known Brownina movement. This motion is probably due to unbalanced molecular blows of solvent molecules, which bat the solid motes about as a tennis racket drives the ball to and fro. The latter conclusion is strengthened by the observation that the smaller particles have the greater velocity. Further proof lies in the experiments of Ramsay and Senter, 1901, who determined the specific gravity of a colloidal solution by two methods, the pycnometer and the hydrometer. If the Brownian movement of the suspensoid particles comes from inherent kinetic energy possessed by them, the blows which they would exert on a hydrometer should cause a different specific gravity reading than in the case of the pycnometer determination. Experiments, however, indicate that each method gives the same specific gravity for a given solution. Consequently, it is concluded that the suspensoid particles derive their energy from that of the solvent molecules. A dilute congo red solution when slightly acidified gives a beautiful suspensoid due to the anions liberated. We are indebted to Dr. Bayliss, the great English physiologist for several important studies of congo red solutions.

It has been found that the individual particles of colloidal solutions carry electrical charges, the nature of the charges depending on the character of the particle and solvent. The like charges on the particles from any given substance cause them to repel each other and thus stabilize the suspension. The origin of these charges is not known, but it is not improbable that they have the same beginning as contact electricity. If an ionogen such as sodium chloride be introduced into the colloidal suspension, the oppositely charged ions resulting from its dissociation, combine

with the particles, that is, positive ions will combine with negative colloidal particles and vice versa, thus rendering the colloidal particles electrically neutral, following which the particles adhere to form larger masses and ultimately settle out, thus destroying the suspensoid. Bayliss raises the question as to what becomes of the other ion which is still free, a point which has not been settled. Surface tension also plays an important role in these phenomena, but its method of functioning is not clearly established The viscosity of the external phase alters the time of settling of small particles in suspension in a liquid.

The reader should note that a suspensoid comprises a liquid external phase and a solid internal phase. On the other hand, we may have a solid as an external phase with a liquid constituting the internal phase. Gels furnish an example of the latter type of contact mechanism. Two types of structure have been postulated for gels in the effort to explain their rigidity and other properties; one, the honey comb or cellular, in which the colloid, gelatin, etc., forms the cell walls, enclosing the liquid phase and providing a rather rigid structure; the other, the sponge type, in which the same relations obtain. The amazing thing about gels is the small amount of solid matter required to give appreciable rigidity to the structure. For example, Gortner and Hoffman, *Journal of The American Society*, 43, 2199, have prepared a two-tenths per cent gel of dibenzoyl-L-cystine in water which is said to be as rigid as a five per cent gelatin gel. When this freshly prepared gel is submitted to suction filtration, a liquid passes through the filter and fibrous crystals of dibenzoyl-L-cystine remain on the filter. This is one of the first instances on record in which a substance of relatively simple chemical composition forms a clearly defined gel. In this case the gel structure is apparently fibrillar.

The phenomenon of absorption appears at the contact surfaces between solids and liquids. It has come to be a trite matter that charcoal, platinum, palladium and many other metals and substances, absorb varying amounts of gases and liquids. The use of charcoal during the war in gas masks is an important application of the principle of absorption. In the case of the best charcoal, the amount of absorption surface exposed by one gram of the material is variously estimated to range from one hundred to one thousand square meters. Strikingly, the absorption of liquids by charcoal is exothermic in character. The following is taken from *Colloidal Chemistry*, Bancroft, 26-27:

Melsens, 1874, found that twenty-five cc. of different liquids, water, ether, alcohol, carbon disulfide, etc., added to ten grams of freshly ignited charcoal gave a marked rise in temperature. A sudden compression of ten atmospheres raises the temperature of water only one-seventieth of one degree, hence an actual rise of 1.16° when charcoal is wetted with water is equivalent to the heat resulting from a sudden compression of 893 atmospheres. Lamb and Coolidge find by subtracting the heat of vaporization from the heat of absorption and assuming this difference to be heat of compression, an attractive force equal to about 37,000 atmospheres when one cubic centimeter of liquid is absorbed by ten grams of charcoal. This is equivalent to the downward pressure of a column of water two hundred and thirty miles in height. Carefully dried cotton as well as other materials evolve heat when wetted. It is believed that the submicroscopic pores of the charcoal function chiefly in producing these remarkable effects. We are tempted to conclude from a consideration of these large thermal changes that such absorption phenomena are the result of chemical rather than physical action.

A suitable lecture experiment illustrating the above is easily prepared by packing a few grams of freshly ignited charcoal in the bulb of an air thermometer made from a Bunsen ice calorimeter to which is attached a capillary indicating stem containing a drop of colored liquid to serve as an indicator. The test tube extending into the calorimeter should be about two-thirds full of the charcoal. On adding one cc. of the carbon disulfide a marked expansion of the air within the bulb is shown by the movement of the indicator drop through a distance of several centimeters.

A drop of a solution of congo red placed on filter paper gives two concentration zones, one colored and the other colorless, the latter being called the water ring. The paper absorbs the color and limits the extent of its spreading. Ink on blotting paper behaves likewise. The character of such absorption is not clear.

Our consideration of suspensoids revealed the fact that the individual particles constituting the inner phase carry electrical charges. If electrodes be placed in such a solution and a current passed through it, positive particles migrate to the negative pole and vice versa. This is called cataphoresis. For example, two electrodes in a suspension of finely divided quartz or shellac with the current passing cause the particles to move toward the positive electrode. Metallic hydroxides form electropositive,

and all metals and metallic sulfides, electro-negative hydrosols. Some dyes are electropositive, others electronegative. Haemoglobin is electropositive and starch electronegative. Obviously no generalization can be drawn at present as to the relation existing between the chemical structure and electrical behavior of these collogens.

It has been found that a liquid will move through a porous diaphragm if an electric current is passing. The majority of substances become negative in water, consequently water is positively charged and migrates through the diaphragm toward the cathode, the process being termed electroendosmosis.

Having so far considered certain phenomena resulting from the contact of two solid phases and that of a solid and liquid phase, we now turn to the properties of contacts between solid and gaseous phases. Here we shall consider briefly absorption, catalysis, the radiation hypothesis of chemical action, triatomic hydrogen and solution surfaces.

The absorption of a gas by a solid such as charcoal has already been mentioned. The mechanism of such a process is still obscure. However, "Langmuir (*Colloidal Chemistry*, Bancroft, 37), considers that any crystal forms a giant molecule and that an absorbed gas forms a compound with the outer layer of atoms, the thickness of the reacting gas film being rarely over one or two molecules thick. Looking at the subject from a kinetic point of view he derives an equation of the form $Q = (a/p+b-cp)$ where Q is the amount absorbed at the pressure p and a, b, and c are constants. There are two independent questions involved in Langmuir's hypothesis, namely, whether the maximum absorption film is only one or two molecules thick and whether this layer forms a compound with the absorbing agent. Langmuir claims that the absorbed film never exceeds two molecules in thickness for plane surfaces, though he is apparently willing to concede a greater thickness for porous substances. There is no question but that the absorption film is very thin."

Bancroft suggests that mercury does not wet glass owing to absorbed gases at the glass mercury contact. It is common knowledge that residual traces of air and moisture remain on glass in spite of extraordinary precautions which may have been taken to insure their removal. In an attempt to test the validity of Bancroft's hypothesis, the writer heated a glass rod and plunged it into cold mercury. The rod fractured, but in no case did the mercury wet the glass or enter the numerous cracks,

though the experiment was repeated many times. The fresh surfaces exposed by the cracking of the glass could not easily have absorbed gases, consequently the results seem to prove that the failure of mercury to wet glass is due to inherent properties of the two materials which we are not able to interpret at present.

The phenomena of catalysis present interesting phases of surface action of which, however, the limitations of the discussion permit but a brief consideration. Heated platinum foil placed in a mixture of air and methyl alcohol vapor continues to glow with a red heat, formaldehyde resulting from the oxidation. The reaction goes on at greatest efficiency when silver is the catalytic agent. The writer finds that a very thin coating of platinum on glass acts in a similar way. In fact, a semitransparent film of platinum undergoes a change in structure during the reaction as shown by a microscopic examination. The continuous film breaks up into an "alligator skin" structure made up of dense and light spots respectively, each spot showing a net-work formation. Part of the structural change may come from an alteration in the glass support, however, the tendency of the platinum to increase its active surface, is qualitatively parallel with that which takes place in the platinum gauze for ammonia oxidation. The increase of reaction surface results in a reduction of the surface energy per unit area to a minimum. This would seem to be an extension of the rule of minimum surface energy, rendering it applicable to surfaces which are functioning dynamically as well as to surfaces which are static. It is hoped that a further study of these thin catalytic films may prove illuminating.

Wendt and Landauer, *Journal of the American Chemical Society*, 44-3-510, passed hydrogen over a 16 centimeter length No. 26 B. S. gauge platinum wire heated electrically to 800°. The wire was contained in a glass tube 26 centimeters long and 15 millimeters in diameter. The hydrogen was activated and when passed over cold sulphur formed hydrogen sulphide. Ordinary hydrogen has no action on sulphur, consequently the activated form is thought to be tri-atomic hydrogen, H_3. Thermionic emission suggests itself as the probable factor essential to the production of this allotropic form of hydrogen.

An attempt has been made to establish a relationship between radiation and thermal reactions. As early as 1860, Harcourt and Essen discovered that radiant energy, light, changed the speed of the reduction of potassium permanganate by oxalic acid. N. R. Dhar, *Z. Anorg, Allgem, Chem.*, 119, 177-8, 1921, points out

that reactions which have the largest temperature coefficients are also most sensitive to light. This confirms the hypothesis of Lewis and Perrin. Lewis and McKeown, *Jr. Am. Chem. Soc.*, 43-1288, hold that radiation is the "origin and cause of physical and chemical change—photo-chemical, so-called when the temperature of the radiation is greater than that of the material on which it acts; thermal, when the temperatures of the radiation and the matter are identical." Langmuir questions the sufficiency of the available energy absorbable by a gas on the radiation hypothesis to account for the observed reaction velocity. Our ignorance of radiant energy prevents a satisfactory conclusion regarding the preceding views. Literally, a ray of light comes to us from Dr. Dayton C. Miller, *Science*, 1922, 1427-426, who has discovered an ether drift effect which is, however, only about one-tenth of the magnitude expected. If confirmed by future work, this discovery will have given us the first tangible evidence concerning that most elusive of all physical concepts, the ether.

The surface of a volatile liquid, water for example, in contact with air, presents a dynamic picture, involving a loss of liquid molecules through evaporation. A solution of salt water under similar conditions will of course lose water molecules, but not so rapidly as the pure solvent, if the temperature and pressure remain constant. This lowering of vapor pressure is proportional to the number of solute molecules present, the latter possibly acting as a screen, thus hindering some of the solvent molecules in their tendency to escape from the body of the liquid. We will remember that a colloidal particle of a suspensoid is probably kept in motion by the molecular blows of the solvent, consequently it is conceivable that some of the particles in the solution, sodium chloride molecules, sodium ions and chloride ions should be impelled a short distance above the solution surface by the blows of the water molecules. It should be noted that the sodium ion weighs but little more than the water molecule. In an effort to test this possibility, a current of air was driven across the surface of the solution into a bunsen flame. The anticipated increase as evidenced by a yellow flame coloration was not apparent. However, surface tension data show a higher concentration of solute at the surface of the solution than in the body of the latter. This may in part be due to the dynamic condition mentioned above.

Kumao Yamakami, *Jr. of Biochemistry*, 14, 193-13, 1920, has found that Barger's micro method for molecular weight deter-

minations functions through osmosis and is not due solely to vapor pressure differences. The writer has verified Yamakami's findings, using a modified surface tension apparatus as described in the *Jr. of the Am. Chem. Soc.*, 42-3-472, but placing a drop of solution in the tip of the cover or support tube and some of the pure solvent or a solution of different strength in the capillary tube. The meniscus of the capillary is now brought to a position near the drop of solution and tilted until the meniscus changes to a plane. After standing an hour, no measurable change in the plane surface can be noted. In other words, where there is no actual contact between solutions of different concentrations, the rate of pure solvent vapor exchange between them is so slow as to render Barger's method impracticable. Consequently, the greater part of the measurable effects observed by Barger must be due to osmosis, as first pointed out by Yamakami.

The last of the possibilities in two phase systems comprises a liquid phase in contact with a second liquid phase. Only those liquids which are immiscible will be considered here. Henris Devaus, *Scientific Am. Supplement*, May 17, 1913, extended Lord Rayleigh's researches made about 1890, who demonstrated the minimum amount of oil which spread upon water would just arrest the motion of camphor particles, which corresponds to a thickness of 1.6 micro-millimeters. (.000001mm.). Devaux used talcum powder spread on water to indicate the boundaries of the oil film and obtained the same value as Rayleigh. We have found Devaux's technique of value in our own laboratory as an exercise in elementary physical chemistry. However, the student's results vary somewhat, the average of a typical series of experiments givine 9×10^{8} centimeters, or .9 micro-millimeters as the average thickness of the oil film. This method is not sensitive enough to indicate a change in interfacial tension on the addition of acids and salts to the water phase.

The thickness of a molecular film of the order of one micro-millimeter has been pictured by Devaux in this wise; "Imagine a film of this thickness over a globe twenty inches in diameter. Then imagine this globe increased to the size of the earth. The oil film will then reach a thickness of about one inch. Magnified on the same scale. $\frac{1}{250}$th of an inch on the small globe is equivalent to $14\frac{1}{2}$ miles on the earth sphere.

Harkins, Davies and Smith, *Jr. Am. Chem. Soc.*, 39, 594, conclude that if the structure of the surface of a liquid is at

first the same as that of the interior of the liquid, then the actual surface is always formed by the orientation of the least active portion of the molecule toward the vapor phase and at any surface or interface, the change which occurs is such as to make the transition to the adjacent phase less abrupt. Mon-atomic and symmetrical atoms yield a displacement of the electromagnetic fields of the atom which is the equivalent of the double electric layer. In water, hydrogen turns toward the vapor phase, oxygen toward the liquid. With organic paraffin derivatives CH_2 turns out, and more active groups, NO_2, CN, COOH, COOM, COOR, NH_2, $NHCH_3$, NCS, COR, CHO, I, OH, or groups containing N, S, O, I, or double bonds, turn toward the interior of the liquid. Such surface orientation must certainly play an important and heretofore unrecognized role in the phenomena presented by surfaces in general.

Emulsions are finely divided suspensions of one liquid within another. In other words, both inner and external phases are liquids. A low interfacial tension between the two liquid phases is essential for the maintenance of a stable emulsion. The substance which establishes the low interfacial tension is called the emulsifying agent. For example, a soap solution will foster the emulsification of oil and water. It is not our purpose to consider emulsions in detail, but rather to call attention to a unique type of emulsion which is transparent and chromatic in character, first discovered about 1912. Dr. H. N. Holmes, *Jr. Am. Chem. Soc.*, 44, 66-70 (1922), has dispersed glycerin in an amylacetate-benzine solution, using cellulose nitrate as the emulsifying agent. The writer prepared the latter by pouring collodion on a glass tray and allowing the solvents to evaporate. Two immiscible liquids emulsified produce a transparent emulsion when the two phases have the same N and the same dispersive power ($N_F - N_C$); a chromatic emulsion when the N of both phases is the same and ($N_F - N_C$) of one phase is much greater than that of the other. Beautiful color effects can be obtained with the above substances by varying the proportions of glycerin, it being possible to prepare a series of emulsions which range from red to violet, constituting a scale or octave of color. These color effects arise from the prismatic or lenticular structure of the emulsion which break up white light into its components, thus rivaling the rainbow both as to its method of formation and its great beauty.

Finally, the case of a liquid phase in contact with a gas phase is of great practical importance. A fog furnishes an example of a liquid as the internal phase and a gas the external. The condensation of fogs by electrical means using high static charges is well known. Foams, in which the above conditions are reversed, the gas comprising the internal phase and a more or less viscous liquid the external, offer at least one interesting application, namely, the fire extinguishing medium, "Foamite," which utilizes the reaction taking place between sodium bicarbonate and alum, forming carbon dioxide and aluminum hydroxide, the latter giving the necessary viscosity to the mixture to insure a good blanket of carbon dioxide foam when applied to burning oil or other flaming materials.

The foregoing comprise but a few from the multitude of interesting phenomena attending surface action. It is the writer's opinion that any marked advance in the direction of a more complete understanding of the mechanism of chemical action, valence and chemical affinity will come from an intensified study of surface action and thermionic emission.

SCIENCE IN THE GRADES

By Vesta Holt

The Dalles, Oregon

How much consistent, logical thinking can a child of nine to twelve years do? Are their observations sufficiently accurate to be relied upon? Is scientific training and observation at an early age advisable?

These questions and many others have been constantly in mind during the two years that our experiment in grade biology has been carried on. In the fall of 1920, this experiment was started, simultaneously, in three school systems of the state under the sponsorship of the Oregon Social Hygiene Society. The writer is in charge of this work at The Dalles, a city of about six thousand. Dr. H. B. Torrey, of the University of Oregon, is father of the idea. There are two aims in view.

1. To give the child a normal attitude toward life processes through acquaintanceship with them early in life as natural processes of all forms of life.
2. To train the child in accurate observation and a logical reasoning from facts to conclusions.

It is this latter phase which will be considered in this article.

The experiment was started in the third and fourth grades last year. This year the fourth grade was followed up and the

incoming third added, hence the fourth and fifth grades this year have had about eighteen months of this work to date. The plan is to follow these grades on through the eighth, adding each incoming third, year by year. The work is handled by a specialist in biology who conducts the class in the regular classroom for one half hour daily. The study is practically all inductive, very few questions ever being answered except by asking other questions leading to the correct answers. Scientific terms are used and scientific accuracy very strictly adhered to.

The results leading toward both aims have been surprising. There is a decided difference between the three ages. It is far less difficult to get the third grade child to try to think than it is the fifth. The fifth grade boy or girl has a better fund of experience upon which to base his conclusions but he is not so mentally awake. There are too many air castles to build and he hates to waste energy thinking if he can find any way to get if "already thought." Some illustrations will show well the ability of these children to observe and reason as well as to give comparisons between the different ages.

Two third grade boys on an afternoon ramble saw a woodpecker working at an old stump and they started an investigation to find out what he might be after. They discovered some grubs which they added were "likely beetle grubs as that was where you usually found beetle grubs." Another boy told of picking up a yellow jacket which had been mashed and finding the stinger protruding. He tried it on his finger to see if it would sting and found that it would, slightly. In discussing the way fish breathed, Harold said the water went in at the mouth and out at the gill openings because the water current moved the fins each time the gills opened.

Such points of observation are constantly coming up. The fine differences in flowers, accuracy in noting bird color and habits develop rapidly after beginning this work. The attitude toward problems is very interesting. It is easy to put a problem before them and they are excellent in figuring out experiments for settling points at issue. A very good example of sustained study of a subject involving a series of experiments and observations, was the work on leaves in a third grade class this year. I find they check little possible loopholes more closely than high school students. Our study of leaves came in as a part of the study of the plant as a living organism. We had demonstrated respiration and found that considerable moisture had collected

on the bell jar. Where did it come from? Various explanations were offered including the possibility of the leaves but the other possibilities of the limewater and the soil as sources, made another experiment necessary. The usual transpiration experiment, with a sheet of ink paper covering the soil, was tried. One boy said water would go through the paper so he tried it out by a method he had suggested himself and found that it was practically waterproof. The presence of starch in the leaf aroused a lot of discussion. They knew that some food materials were taken in through the roots and passed up the stem in the sap. The first conclusion was that the soil was the source of the starch. How could we find out? The suggestion, of course, was made to test the soil for starch. Another question arose—starch would not dissolve, could it go into the roots? The boy trying the test of iodine on the soil had a lot of fun because the rest could not tell the soil moistened with iodine from that moistened with water except by the smell. They did not believe that soil had starch in it but it was so dark naturally that the results were not very conclusive. They turned to the other problem. This settled very conclusively that even if there was starch in the soil, it could not go up the stem as the water colors which were insoluble had no effect upon the Wandering Jew slip, while the soluble red ink colored the leaves noticeably. Where did the starch come from? "The air." That met with lots of objections. "Well, then they must make it." All right, what did they use? I find it possible to introduce a little chemistry way down in the third grades and, while they can not grasp the whole idea of chemical reaction, they realize a little of the marvel and importance of the leaves when they can put a gas with ordinary water and make starch. Do all leaves do this? Is it being done all the time? Of course, tests on variously colored leaves settled the first point easily. In all these starch tests on leaves, the children are very particular that no sleight of hand performances take place—they must see every move. I had made a check test with cornstarch first and they had to be assured that there was no possibility of this cornstarch getting on the leaf we were testing. Also, in testing different leaves they were not willing for the same alcohol to be used in the removal of the chlorophyl for fear some starch might be transferred from one leaf to another. It always seems advisable to use the materials at hand for experiments in so far as possible. In the photosynthesis experiment, they objected to the use of blotting paper for fear it would

absorb the starch and some objected to ink paper as it might cut off the air. They finally agreed on strips of black cloth. They objected to pinning it on for fear the starch would leak out the pinholes.

George was telling of locating all the vital organs of a pig when they butchered. In naming them he mentioned the gizzard, then corrected himself, saying that a pig had teeth for chewing his food so he did not need a gizzard.

Fourth grade children use more comparison in their descriptions, and some of these comparisons are immensely interesting, for example: "Spider eggs are about twice as big as a pin point and look like goose's pimples." When we opened a pigeon's gizzard and found rocks it aroused quite a bit of discussion about what other animals had gizzards. Albert said that if we tried to use rocks to grind up our food, we would chew up the rocks and they would not do us any good. The question of the course of the water through the gills of the fish had been discussed with no definite results. Outside information disagreed and it had to be proved definitely. Suggestions were called for. Clarence suggested that he would hold one of the fish so that its mouth was under water and the gill openings out. In this way he could actually see the water coming out at these openings, if it did. He tried it and after about three attempts succeeded in proving his point without question. Our fish had been in captivity so long that they were not very wild and this one breathed quite normally. One youngster had told a story he had read of how ants form a bridge of ants to cross water. Esther wanted to know how the ants in the bridge got across.

Some of the most interesting thinking has been done by the fifth grade children. We have been studying eggs and their formation, fertilization and development. I have had questions asked by twelve-year-olds about sex determination—wanting to know what there was in the tiny cell which caused one egg to hatch into a rooster and another into a hen—entirely away from popular questions and theories as to shape, etc. They have also asked if it would not be possible to remove the eggs from the hen and fertilize them artificially—"It would save the hen a lot of work." Our study of enzyme action in changing starch to sugar has aroused a lot of chemical questions. They are intensely interested in chemical reactions and what causes them.

As an illustration of observational powers, Charles told of a

mole "drowned out" with the garden hose, appearing with the water at a hole a block away. He was there and saw the ground begin to move and the mole appear. Then he investigated and found out where the mole came from. One boy described the growth of the yeast in this way: "The yeast grows by growing buds on the top story or the bottom story or either side story." Here is a paper from a fifth grade girl. It was written from her own observation and study and is copied with her own spelling and sentence structure:

"Gophers and moles are little ground animals. The gopher lives on roots and vegetables, on the other hand the mole eats insects and the worms that he gets in the ground. The gopher has pockets which he uses very much for making his house to carry dirt and he uses them to carry his food which would come in handy in storing away his winter food suply.

"The mole is dark grey in collor and when you rubb his fur it looks like silver it is quite like changeable silk. The mole's hole is not as deep as the gopher and the ground where his home is made is not raised up like where the gophers home is.

"The mole has very wide hands for such a small animal. The mole does not do any damage and is a very good friend of the farmer but the gopher does just as much dammage as possible and are killed whenever he comes in contact with the right person."

This is the conclusion to the osmosis experiment written by a fifth grade girl before any discussion of the meaning of the results had been taken up.

"By this experiment we found out how sap rises in the plant. When we put sirup in the tube and water in the glass the sirup in the tube rose and when we put water in the tube and sirup in the glass it fell. This shows that sap is on the inside and the water is on the out, that the water goes into the sap and pushes it up but if the water was in the plant and the sirup was on the outside the plant would dry up because the water fell when it was on the inside."

If there is ever a time in a child's life when every creeping, crawling, flying, growing organism is of interest to him, it is during his years in the grades. He can ask questions and those questions are not restricted by the many false notions of propriety which hinder the progress of older children. They want to learn and since they have no reputation to live up to, they are not afraid to show their ignorance. Furthermore, they love

to display their own knowledge, meager though it may be.

Formerly, the child who wasted his time catching slimy, crawlly things was in some way lacking. It "wasn't nice." Now that child has an asset that is placed at a premium. Instead of being driven away from the school, he is brought to a realization that there can be some connection between his outdoor world and that prison, school. There is much to be seen and learned out of doors and where can you find any better environment for the growing child? Where is there a better place to train his powers of observation? If there is any mental characteristic which needs development for future use, it is the ability to work out the reasons for things, to draw correct conclusions, to think logically. Why should not this training start early with a natural interest to build upon? The results of the two years' work here seem to indicate that science in the grades is very much worth while. We are teaching biology but we are arousing interest in all lines of science, we are training observation and arousing a scientific attitude toward things, and we are developing a group of young thinkers who are going to make our high school science teachers "sit up and take notice" when they arrive at the high school age.

READ THE STORY OF PEAT

The United States contains 12,000 square miles of unused peat land, an area more than 10 times that of Rhode Island, capable of yielding 14 billion tons of fuel at a cost of $1.50 to $5 a ton, according to a comprehensive bulletin on the subject just issued by the United States Geological Survey. The deposits are on the surface and lie in the New England, Atlantic Coast, and Great Lake States, most of them in regions remote from coal mines. This bulletin, which is the most exhaustive American work on peat and required two years for its preparation, points out the location of thousands of deposits, owned by thousands of farmers and other landowners.

Fifty million tons of peat is used annually as fuel in Europe. Peat is suitable also for use as a fertilizer and in promoting the intensive growth of truck crops, both in greenhouses and in open fields. Manufacturers of commercial fertilizers are paying as much as $10 a ton for good peat. The present output is about 100,000 tons annually. In some parts of the country the yearly proceeds from the intensive cultivation of peat and muck soil for lettuce, celery, and onions amount to more than $500 an acre.

Those who own or are interested in deposits of peat or muck may obtain free copies of the bulletin by addressing the U. S. Geological Survey, Washington, D. C. It was prepared by C. C. Osbon and is published as the Geological Survey's Bulletin 728, entitled "The Occurrence and Uses of Peat in the United States."

THE TEACHING OF GEOGRAPHY IN THE HIGH SCHOOL

By V. J. Brown

Community High School, Watseka, Ill.

When I first received from your chairman an invitation to present before this meeting a ten-minute paper, I felt that there had been some mistake. I have had that feeling several times since and find no small amount of the same existing at this moment. Perhaps when I shall have finished you will have a similar feeling. If you do I shall not question your judgment. With this attitude of mind I wrote to a friend who is interested in the teaching of geography and received the following suggestion, "You may know the character of the meetings to have changed, but at the meetings of the Academy of Science which I have attended all the papers have been on original investigations along scientific lines." I then wrote your chairman and suggested that there might have been an error and that any paper which I might present would, of necessity, be pedagogical rather than scientific. Having his assurance that such a paper would be acceptable and in place I have made bold to discuss before this meeting "The Teaching of Geography in the High School." I am not a scientist. I have made no original investigation along scientific lines. However, if this Academy is interested in the decline of a subject which should retain a place in our high school course of study, a subject which should be a science, but is not as now taught, then this paper may have some slight claim to a place on your program.

An examination of the "Report of the High School Visitor of the University of Illinois for the year 1920-21" shows that of the 530 accredited high schools in the State of Illinois, 413 offer courses in physiography, and 367 offer courses in commercial geography. This means that approximately 70-80% of our accredited high schools offer courses in geography. At the first glance this seems not such a bad showing for the subject; but when we consider that the courses are almost entirely elective, that 334 of the schools offering commercial geography and 381 of the schools offering physiography offer but ½ unit, that of the 31 schools offering 1 unit almost 50% are in the City of Chicago, and that the courses are found everywhere from the freshman to the senior year inclusive, the showing is much less favorable.

To determine the qualifications of the teachers handling the subject and the methods used in teaching, would be an interest-

ing investigation. The reports of the attendance of teachers in the Geography Section of the High School Conference for the years 1916-21 inclusive, and the report of the Secretary of the Committee on the Appointment of Teachers of the University of Illinois 1920-21, may serve to indicate something of the conditions. The number of teachers registered in the Geography Section of the High School Conference for the various years was as follows:

1916	1917	1918	1919	1920	1921
16	19	8	13	26	25

In every case this is the lowest registration in any section of the Conference and is less than the number of schools offering unit courses.

From September 1, 1920 to September 1, 1921 the Committee on the Appointment of Teachers at the University of Illinois received 2,079 requests for teachers, of which 1,328 were from Illinois. Of these requests only twenty-one included georgaphy. One was for geography alone, four for geography as a major subject, and sixteen for geography as a minor subject. Of the 220 candidates enrolled with this committee and graduating in 1921, one woman was registered in the Department of Geography and she was placed in either a college or normal school. The Secretary of this committee reports a total of only two geography positions filled last year. While this data is not conclusive it certainly indicates that geography in the high schools of Illinois is being taught by a group of teachers who are ignorant of both subject matter and method, and who have little or no interest in the subject. Geography in our accredited high schools is a "fill in" subject wished upon the unfortunate teacher who happens to be available at the time and place best suited to the daily program. Under such conditions "The Sick Man of the Curriculum" shows no improvement, and we may as well prepare ourselves for the worst.

It is not the purpose in this discussion to defend either the right of geography to a place in our high schools or the proposition that it should be taught as a science. Both of these things have been assumed. Neither has it been thought necessary to distinguish between physiography and commercial geography. It is believed that the suggestions submitted may be applied equally well in either subject. If, then, geography is to be taught as a science what shall be the method of attack? Psychologically as well as scientifically the pupil should be in-

troduced to the subject matter of geography through the study of pertinent problems.

These problems may be simple and limited in their scope or they may be as broad as the ability of the class and the nature of the subject matter will permit. Their solutions may come through the examination of subject matter, through laboratory work, or through field trips. The essential thing is that the pupil solve the problem for himself under the guidance of the teacher. Facts, details, definitions, and principles are subordinate to the solution of the problem.

But the lessons will develop certain facts, definitions, and geographical principles which need to become the permanent possession of the pupil in order that they may serve as a part of his working equipment in the solution of further problems. These definitions and principles are a minimum requirement which each pupil should master.

The more enthusiastic advocates of the problem method would have us believe the necessity of memorizing and drill ceases with the introduction of this method of teaching. But until the Law of Recall shall change, the necessity of drill, like the poor, "ye have always with you." Since these facts, definitions, and principles are to be a part of the child's working equipment they should be first, scientifically accurate, and second, within the realm of the child's experience and vocabulary. Half truths are always dangerous. It is not true that temperature decreases as latitude increases. It is true that temperature tends to decrease as latitude increases. It is good science to leave a principle in such form that it is subject to enlargement. It should not be left in such form that it becomes subject to correction.

One of the worst faults of our science teaching has been the assumption that science, to be science, must be abstract and expressed in abstract terms. The following definition occurs in Mill's International Geography: "Geography is the exact and organized knowledge of the distribution of the phenomenon on the surface of the earth, culminating in the explanation of the interaction between man and his terrestrial environment." Such a definition may be in place in such a book, but we have carried too much of such so-called "scientific language" over from our colleges and universities into our high schools. Geography deals with commonplace things and phenomena. It should be expressed in commonplace language. If the solution of prob-

lems has developed the necessary facts, definitions, and principles, and these have become a part of the pupil's possessions, he now has the tools for attacking larger and more complex problems each of which may in turn develop new principles.

In order that geography may be taught in this way, it would be necessary that we have, first of all, a group of trained teachers. This would mean teachers not only familiar with their subject matter but also trained in scientific methods of presentation. The possession of geographical knowledge is no more assurance of the ability to teach than the mere possession of capital is assurance that the holder is a financier. Second, there needs to be within the state an organized body of teachers who will accept the responsibility of guiding and developing the teaching of geography. Whether or not such a work is within the province of the Illinois Academy of Science, I am not prepared to say. But unless some organized group shall attempt this work, geography will never play any vital part in the education of high school pupils.

CREATING INTEREST IN CHEMISTRY

By Ray E. Hoffman

West Technical High School, Cleveland, Ohio

To many students chemistry is a curious study, to others it appeals because of their imagination for they like to think of things they cannot see, and to still others, the subject is a very difficult, uninteresting bore. There is no use in studying chemistry unless one can have a good time by himself, just wondering, and thinking about things, and guessing out as best he can, how they happen. No one doubts the importance of the subject. We must bring a lot more chemistry into daily life than we now have, but experience and observation lead us all to conclude, that it is not always an easy task. Several years of experimentation have convinced the writer that there are many ways of enlivening the subject, without fear of diminishing its *intent*, to a degree of creating an intensive interest in all but the unusual student. It is the purpose of this article to present some of the methods found practical for the accomplishment of this desirable end.

The usual school program assigns a double period twice a week for laboratory work. The average laboratory manual presents a series of experiments based completely on the text content, many of the experiments being cut and dried, very difficult and uninteresting, sure to be forgotten by the student as soon as he

is given the opportunity to forget them. But why not insert along with the most important of these such experiments as the following: Testing Cigarette Papers for Arsenic; A Qualitative Examination of Urine for Sugar, Albumin, Indicans, Acetone, Diacetic Acid, etc.; Preparation of Parchment Paper, Guncotton, Collodion, and Artificial Silk; "Testing for Alkaloids such as Nicotine Caeffine for Acetanilide, etc., and testing Well Water for Degree of Hardness, Organic Matter, etc.; Determination of Composition; Deposit from Teakettle; Testing Soil from Garden; Testing Foods for Adulterants, such as canned milk for formaldehyde, hamburger for sulphites, coffee for chicory and roasted cereals, vinegar for caramel and per cent of acetic acid, candy for coal tar dyes, etc. These are only a few of a long list of experiments that can be used in this way. Such labatory work not only creates an interest in the subject but makes the pupil see its practical side, gives him something to discuss with his friends and family, and makes chemistry the study most alive in his experiences.

Every teacher gives occasionally a quiz or examination. At such times pupils fear the subject unless some method is devised to interest them in this phase of the work. Why not modify the usual routine quiz by giving a one-word or so called psychological quiz. Pupils are always delighted with riddles or conundrums and take pleasure in answering such questions as: Water boils at 100°, 273°, 212°, F.; Citric acid is an organic acid from apples, sour milk, lemons, vinegar; N_2O, NO, NO_2, N_2O_3 is frequently used by dentists as an anaesthetic; the recovery of iron from its ores is an application of the principal of oxidation, displacement, reduction, electrolysis. Does not this type of question serve a better purpose than: "What is the boiling point of water?" or "Name an oxide of nitrogen used as an anaesthetic?" to this end, I have divided the textbook into four divisions making up a list of twenty-five such questions from each division so that the pupils encounter such a quiz four times during their elementary course.

Then, too, if you wish to surprise the class, to develop thought intensely, and to secure some real hard work for a few minutes give them a quiz occasionally composed of only thought questions telling the class that they may use their books in solving the questions or even to the extent of discussing them among themselves, the teacher leaving the room. Examples of such questions are: Why is the bottom of a balloon left open and not

tightly closed?; or: Show how the oxides of nitrogen illustrate the Law of Multiple Proportions; or: How would you determine whether a given solution was unsaturated, saturated, or supersaturated?; or: Account for the fact that ferric chloride, a common salt, tastes sour and behaves like an acid when in solution; or: Distinguish between a metal, a mineral, and an ore; if NaOH and KOH were the same price per pound, which would you use as a base, and why?

No textbook is complete; that is fortunate for the teacher in that it gives opportunity to do some unusual work with extra assignments. These may be made as oral reports or in theme form, it often being possible to cooperate with the English department in allowing the student to secure credit for the work in his English class as well as the chemistry class. Students are always interested in hearing and even giving reports on such topics as "Synthetic Precious Stones," "Liquid Fire", "Radium," "Rubber," "Poisonous Gases Used in Warfare," "Iron Rust and its Prevention," "Gas Masks," "Making Mirrors," "Electric Furnace Products," "Ink," "Cement," "Dyes," "Glass," etc. The student is always willing to make such reports if he knows he is to get credit for the work. I have many times succeeded in enlarging the importance of this phase of the work by getting some local paper to print the best themes, or some local organization to perhaps offer prizes. In one city we succeeded in getting a steel mill to give the boys $25 in cash prizes for the best theme on "Iron and Steel," and a dry goods company $25 to the girl for the best theme on "Textiles." Printed copies of the prize themes were made and distributed among those who worked for these companies. All students who entered the contests secured credit for their work in English as well as Chemistry, and those who did not desire to enter the contest were allowed to select other topics and the best themes were printed in a local newspaper.

Furthermore, those who teach in the city have opportunities to visit industrial plants. It is always worth while to take a class through a modern filtration plant, a coke plant, a steel mill, a paint factory, etc. This breaks the monotony of the class room work and adds in many ways to the interest of the subject. It should be required of the student to take careful notes on such trips, to be made use of later for written work such as a "Flow Sheet for the Water Purification in the city of .....," or a theme on "A Trip Through a Steel Mill."

Where is the student who does not enjoy magic? How simple many of the magician's tricks appear and how easy for the student to join their ranks if the chemistry teacher only makes certain easy demonstrations as they pursue their study. When studying oxidizing agents show them how to make fire under water with potassium chlorate, phosphorus, and sulphuric acid; when studying indicators, show them the famous water to wine trick; when studying hydrogen sulphide, show them how to mysteriously tell fortunes with lead acetate; when studying crystallization show them chemical snow storms and submarine gardens; when studying displacement, show how to coat copper pennies with mercury and caution them not to try and pass them on to the street conductor for dimes. These are only a few of such short experiments, and each one can be used to emphasize some chemical principle that otherwise the student would have forgotten.

One of the surprising results of such methods of teaching the subject is that soon many students will be collecting laboratory sets of their own, and this is good proof that the instruction has been successful. For how much real chemistry can we expect a pupil to learn in one year in high school! If, however, we can create in him an interest for the subject, so that he will continue its study, we have accomplished a very desirable end that will lead him on to better things.

NEW YORK ONCE UNDER WATER

Though many people have a general idea that large parts of the United States have at times in the past been covered by the ocean, it is perhaps not so generally known that the continent is even now rising in some places and sinking in others. Not so very long ago, in a geologic sense, the Hudson River flowed through a deep canyon or gorge at New York City. Soundings show that this ancient gorge extends through New York Harbor and far out to sea. The land surface in this region has evidently been lowered, allowing the ocean to creep in on the land, fill the old river channel, and in places wholly submerge it. The ocean at one time submerged more of the land about New York than it does now, for in excavations made for some of the skyscrapers the remains of oysters and other salt-water animals have been found. By the nature of fossils thus found the paleontologists of the United States Geological Survey have been able to tell approximately when and how far the ocean invaded the land. They have found evidence of a submergence that was wider and older than that which now floods the ancient Hudson River gorge. New Yorkers need not, however, feel alarmed about the ups and downs of their island, for though this submergence is not so very old geologically, the geologist thinks and speaks in terms of thousands and even millions of years.

NAIVE QUESTIONS AND SCIENCE TEACHING

By Thomas H. Briggs

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The dual purpose of the teaching of all subjects, especially of science, is to furnish worth-while subject-matter and a method for future independent work. When the method of the scientist is analyzed its beginning is found always to be in an alertness of mind about objective phenomena that results in questions. It is in just this detail that education seems lamentably to fail. Hundreds of adults are found to have a more or less satisfactory knowledge of facts, scores are industrious at set tasks even though they may be meaningless, dozens understand principles in a general way, and one is keen to see things for himself, find problems, and analyze them suitably by selecting from the questions that his brain invents. Science teachers have frequently commented on the paucity and irrelevance of the questions asked by pupils on field trips, and research professors rejoice at the rare student who finds and analyzes his own problem, demanding from them only opportunity, time, encouragement, and direction for its solution. This paper purposes to consider the naive questions of adults when confronted with a novel situation, in the belief that they will throw some light on the causes of mental passivity or of dependent industry.

Thorndike has shown that habits are formed in the lowest animal life to the highest by action, either chance or intentional, being followed by satisfaction. The "satisfier" may be to a bodily need or, in the case of *homo sapiens*, more frequently to an intellectual need for an answer to an enquiry. In varying degrees man is uncomfortable if he does not know what his companions know, or if he can not find answers to the questions that spontaneously rise in his mind. It is desirable in planning economical instruction to know what sorts of naive questions the human mind frames and to consider if they fall into any kind of orderly category.

Some ten years ago, interested in this problem, I began to test in an informal way the adults with whom I came into frequent contact. In this testing, which has been continued from time to time ever since, I have used a number of novel objects, but have had most success with a unique substitute for a back collar button, a small piece of metal doubly curved

so that one end would catch under the shirt band to prevent the collar's "riding" and the other would hold out a turn-over collar so that the necktie would slip easily; a circular slide rule; and a "Lock-Tite" tobacco pouch, which has since the experiment become commonly known. The method was to present the object to an acquaintance, a fellow teacher or a graduate student of education, and to note the questions that he asked or that he betrayed by his actions. It very soon seemed clear that the reactions were of especial importance to the method of science teaching. Gradually the questions fell into a hierarchy, which will be presented presently; and although no detailed count of each kind was kept, it is clear that the frequency decreases in a sharply descending curve from the first type of question to the last.

Nothing is more noticeable than the variation in intensity of interest aroused by the casually presented and novel objective phenomenon. A few subjects turned it over for a moment and politely handed it back with, "What did you give me this for?" Others asked one or more questions, some with a dependence encouraged by years of being poorly taught seeking the answers from the experimenter, others demanding the satisfaction of independent discovery. The number and kind of questions seemed to result from any one of several causes. The first cause of all is a mental alertness, a desire to know, the annoyance of being ignorant. This attitude is in some individuals strong only in the field of their particular interests; in others it is general, resulting in a breadth of information and a closely related and consequent culture. What an improved race of intellectuals we should have if this general curiosity could be made common!

A second cause of questions is a perceived relation between the object or the experiment and oneself. In rare instances the subject being highly self-conscious refused to express or reveal his naive questions, apparently fearful that he might betray some discreditable intellectual weakness. Perhaps this attitude, too, was the result of unhappy experiences as a pupil under an unsympathetic and caustic instructor. Usually, however, if the subject perceived or could be made to perceive some relation between the phenomenon and himself, his questions were multiplied and he persisted in his enquiry to satisfactory answers.

In one instance it was interesting to note the results of a combination of the two causes mentioned. A man keen of

intellect and ingenious with mechanics was handed the tobacco pouch. Having quickly answered the simpler questions, he was puzzled to find an explanation of the principle involved, which both his habit of questioning and his former experiences demanded. Three times defeated he laid the problem aside as not worth his time, and three times his intellectual curiosity and his annoyance at being baffled drove him back to achieve success. This habit of persistence yoked with the habit of enquiry goes a long way toward making the scientific attitude. It is most likely to result if "satisfiers" can be assured to naive questions from early years, for "satisfiers" develop habits and "annoyers" inhibit them.

A third cause of lively interest and resulting questions is an active phenomenon. At every exhibition spectators are found crowded around a spark plug in which a spark is leaping or a hutch of rabbits nibbling their food, while the silent engine or the stuffed monkey draws only those who have already a developed curiosity. In my experiments an unfailing stimulus to interest was the rotating of the slide rule or the unlocking of the tobacco pouch. Every science teacher has noted the greater effectiveness of showing a moving amoeba or a machine at work rather than a stained specimen or a machine at rest. The suggestion is strong that in the classroom interest should be stimulated whenever possible by exhibiting in action the object to be studied.

In the hierarchy of questions the simplest and by far the most frequent is: "What is it?" or "What is it for?" An answer explanatory of the function, like "Tobacco pouch," satisfies both questions, but it was astounding to find that in many instances a technical name meaningless to the layman leaves him content. But we find a similar situation in some science teaching; the pupil learns that something is called *agaricus campester*, *toxostoma rufum*, *cam*, *cathode*, or *hormone*, and then such curiosity as may be had subsides. The satisfaction doubtless lies in the comfort of knowing something that others about one know and in a sort of intellectual snobbery that permits gloating over the ignorant. Stopping at this point results in the superficiality revealed when inquiry is made as to exactly what these things are and how they function. Ask a half dozen acquaintances just how we get electric lights or what fermentation is, and the answers would be amusing if they were not such pathetic commentaries on the way some schools teach or most adults forget.

The satisfaction or the pride in the knowledge of mere names, which it must be admitted often passes as current coin in polite society, is valuable in the science class only as a basis for building up interests in higher types. Beginning here, the wise teacher permits, encourages, and assures satisfying answers to all sorts of questions. However foolish or irrelevant they may be, some satisfaction, much privately given, must be provided or else the young pupil first fails to voice his questions and finally ceases to raise them definitely even to himself. In a college biology class the professor provided the students with specimens for the microscope and bade them observe; but lacking definitely formulated questions they wasted precious laboratory hours and learned little. The professor was conscious of the higher types of questions that he desired the students to find answers for, but they were not. They acquired little of information and less of method because they were not permitted, encouraged, and directed to use the method natural to human learning: the formulation of a problem, an appreciation of its worth, and then an attempt at solution. Some teachers at early stages encourage the timid in the formulation of definite enquiries by a question box; others are able to develop directly the habit of asking for information. But clear and definite questions beyond "What is it?" are necessary if worthy and economical learning of subject-matter and of method is likely to follow. Voiced curiosity in one student stimulates enquiry in others, partly by suggestion and partly by the abhorrence each Ego has of not being informed equally with its fellows.

The second question in the hierarchy, second lowest in frequency and highest in importance, is, "How does it work?" or "How is it used?" Almost invariably when the unique collar button, the circular slide rule, or the tobacco pouch was shown, this was the naive question that followed enquiry as to what the object was. This clearly shows a higher level of interest, and its answers are of greater worth. As a matter of fact, probably a majority of pupils who take first-year science in high school will find a knowledge of what things are and how they work amply satisfactory in life. Higher questions are raised only on higher levels of intelligence. A class that is passive and patient under explanations of principle will be eager to observe an amoeba ingest a particle of food or even to watch an instructor set a piece of apparatus to work with an explanation of what

it is used for. It is quite possible that in the hope of developing "real scientists" of all pupils teachers with their optimism have failed to appreciate the importance of the answers to this type of question. Adequate for many, they are for all basic to advance learning.

The third question, if interest persisted so far, was, "Can I work it?" Often it was expressed by a reaching for the object and a turning of the dial or a pulling of the pilot tag. There is here, as in the first question but stronger, a tacit egocentricity. It results in the satisfaction of the instincts for being a cause and for activity. These instincts are obvious when watching a person attempt to untie a difficult knot; one can hardly restrain himself from making the attempt. At the Atlanta Exposition the most popular feature in one of the government exhibits was an instrument that would show simple moving pictures when an individual turned a crank. The pictures were merely of a postman performing his routine duties; so obviously the attractiveness of the exhibit was due to the fact that each person could "be a cause" and make the instrument work. I have seen a science class grow lethargic while the instructor did for their edification what they themselves could just as well have done and what for a few minutes each pupil instinctively desired to do. Of little value except as causes, the instincts have manifested the means of arousing other interests and leading on to higher mental activities. It is obvious that so far as feasible pupils should be permitted to touch, move, and "monkey with" specimens, instruments, and machines. In his *Animal Intelligence* Thorndike makes it clear that primates learn fast because of their persistent instinct to do just these things; and there is a good deal in common in the learning by lower animals and by the most intellectual of us. When pupils "fool with" specimens and machines, or set up apparatus and use it as they will they develop an interest, they learn a good deal (witness the boy and his wireless set), and best of all they raise for themselves innumerable questions. It is the wise and the highly successful teacher who can without discouragement or undue repression satisfy these questions so that the habit of raising them is established and at the same time lead the pupils to recognize the value of the more important ones in leading toward a commonly desired goal.

The question fourth in order is, "What makes it work?" or "What is the principle involved?" Although often and

unwisely the beginning of science instruction and inevitable somewhere in every topic for secondary and higher schools, this question is not frequently raised by intelligent and well educated adults when informally confronted by simple, novel objective phenomena. My subjects were for the most part content to know that the queer object is called a slide rule, that it is used, among other things, in the rapid computation of percentages, that it is operated by turning the dial thus and so, and that they themselves can find answers with it; very, very few asked or seemed interested in the underlying principle, though none of those who were asked could explain it. A slightly larger per cent were interested in the principle of locking the tobacco pouch. In other words, science had not been successful either in high school or in college with these superior adults in its attempt to inculcate the habit of demanding the principle involved. It is not unreasonable to suspect that the cause of this indifference lies partly in the emphasis on principle before the earlier questions in the hierarchy had been satisfied and partly in the failure to encourage naive questions by providing satisfactory answers to those raised whether they were the ones anticipated and desired by the instructor or not. If there were more generally employed the collecting instinct, especially in the junior high school period, and the instinct of rivalry to accumulate or consider more specimens than anyone else in the class, the later interest in underlying principle should reasonably be greater.

Science teachers always go to the fourth step in the hierarchy and expect their pupils to take it also, but how few go on to ask the last and highest question, "What extensions of this principle are possible?" This is the field of the inventor. In my experiments no one expressed this question concerning the collar button substitute, perhaps because the principle has a unique application, or about the circular slide rule, though the principle can easily be extended to several new phases of educational measurements; but three men proposed, each to satisfy a need of his own, the extension of the locking device on the tobacco pouch to a sleeping bag, to military leggins, and to a football lacing. To a layman it seems desirable that pupils should recognize that this highest type of enquiry exists and should be frequently considered. That they may have the satisfaction of success, situations should be prepared that lead to easy rediscovery of extensions of a principle. This will result in some

appreciation of the work of the inventor and it will lead to a satisfaction which may encourage future independent attempts. The average teacher can hardly do more.

It is quite possible that any observations of the naive questions of educated adults may differ from those of immature pupils. But the results are at least suggestive of a method that can be followed by anyone who is interested. If the five types of naive questions reported or other similar ones are found to be common among secondary school pupils and to form a hierarchy, they will afford valuable suggestions to teachers of the order in which phenomena may be considered in science classes to insure the economical acquisition of information and of methods of procedure. Whenever possible, the habits of nature should be followed rather than combated.

THE SCIENCE REFERENCE LIBRARY

By Grace M. Harper

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In no other department except English is such a wealth of material available to teacher and student as in science, yet many otherwise well-equipped schools fail to amass a creditable science reference library.

The present article is a resumé of various plans, most of which have been used by the writer during the last three years. The ultimate purpose throughout has been to make science divert a little more of the pupil's outside time and establish in him a habit of interest in current scientific problems. From the standpoint of the science teacher this aim involves a consideration of the following topics:

Scope of Article

I. Standards observed in selecting reference material.
II. The securing of reference material.
III. Making material available for student use.
IV. Securing systematic use of current reference material.

I. Standards

1. Perhaps the best and only standards that need be applied to a book or magazine are its accuracy of scientific statement and its "readableness" from the child's viewpoint. The first of these probably possesses less importance than we usually attach to it. Many a Gadgrindian scientist has in childhood pored over the "Rollo" books and "Twenty Thousand Leagues under the Sea" without permanent injury to his later discrimina-

tion. To be sure, nothing that is grossly incorrect or unscientific should be placed in the school library, but it may be necessary to include some reading matter that is considerably below the standard of *the best*, according to mature scientific definition. We must, in any case, provide material of sufficient range to allow the pupil to find that which is suited to his mental development. Magazine and newspaper articles, in particular, can well be used in teaching discrimination in the relative value of printed items. The pupil learns to strike a balance between the scepticism that rejects every new or unfamiliar statement and the credulity that accepts anything "in print." The pupil's reaction to a pseudo-scientific article, in fact, gives an excellent opportunity for testing out his grasp of scientific principles.

Kind of Material Provided

In choosing books for the pupil we do well to remember that he is in the romantic age with a capacity for interest in the romances of invention, a tendency toward "hero worship" of the pioneer scientists—if only their lives and struggles be readably presented—and a desire to plumb the mysteries of energy and matter that gives him a derived interest in the latest theories of science. For the practical, matter-of-fact type of student we must, on the other hand, provide some technical works of applied science in the special fields. The pupils themselves will usually furnish very good lists of books they have enjoyed reading and when the teacher can select from a number of these lists there is little doubt that the books will be kept in circulation.

The reference material that the science teacher can collect and systematically relate to the class work falls into the following classification:

a. Books that present applied science in a manner that is sufficiently "popular" to make an appeal.
b. Magazines that contain "popular science" articles.
c. Government bulletins, catalogues, pamphlets, etc.
d. Clippings from all available sources.
e. Books and magazines of a more technical nature that deal with special fields of science.

II. Securing Books and Magazines

If the appropriation for reading matter is inadequate, various plans may be used to supplement the stock.

While it may seem outside the field of the present article, a word might be said about the home library. Every effort should be made to get readable scientific books and magazines into as many homes as possible. Fathers and mothers without scientific

training can often enjoy the reading matter that appeals to their high school sons and daughters, and an immeasurable growth results from family discussion of such reading matter. A great deal can be done through the Parents-Teachers' Associations. Parents are usually glad to be given suggestive lists of books or magazines, especially around Christmas time. The results are more noticeable if pupils have been encouraged through the school to ask for or make presents of such a nature. Clubs can often be formed among the pupils and the three or four magazines received by the group passed from member to member.

Supplementing the School Library

Most schools provide for the purchase of books more liberally than they do for the purchase of magazines. Even ten or fifteen dollars spent in books each year will furnish a nucleus, although considerable supplementing will be required.

If the school is in a town with a progressive public library, the directors are often willing to buy books recommended by the science department of the school, provided the books are of sufficiently popular treatment to keep in circulation. Some libraries lend the school sets of books chosen by the teachers of the various departments. If no such ideal cooperation between the school and the library is attainable, the school can at least have one or more library cards to be used by teachers in placing on the shelf desired reference books not owned by the school. As a last resort, there are the pupils' individual cards. By concerted action on the part of borrowers, a number of extra books on a special topic can be transferred to the school library shelf for a couple of weeks. The teacher must, of course, know the resources of the public library in each topic assigned for collateral reference work. However complete a cataloguing system the public library possesses, and however well trained the pupils have been in its use, the teacher's card catalogue files should include all articles or topical references she expects to use during the year.

In a community where no public library exists, as may sometimes occur in the case of the rural centralized high school, there is normally such an eagerness for good reading matter that a school bazaar, home baking sale, candy sale, etc., for the purpose of providing library funds is generously supported.

Magazines

As was suggested above, there is often a failure to provide

current reading matter for school use. It can, however, usually be obtained by one of the following methods.

a. From school-fund appropriation (if such exists) for books and magazines.
b. From "library fee" imposed on pupils who register in science courses.
c. From fund formed by payment of dues in a science club that combines social and informational features.
d. From fund subscribed by members of community, Mothers' Club, etc., or earned by members of science classes.

Of the four methods suggested, (a) is most generally used, though (c) will be found to promote a spirit of cooperation and pride of possession not fostered by any of the other methods. Even such a nominal sum as twenty-five cents a year from each member will provide enouch magazines to circulate during study periods, though there will be certain favorite magazines for which there is an overdemand.

Bulletins

Government bulletins, pamphlets, catalogues, etc., are usually furnished on application or at a very nominal cost. The collection of such material is a simple matter, though its classification, which will be considered in the next section, is far from simple.

Clippings

Clippings, likewise, are more easily collected than catalogued, through eternal vigilance on the part of the teacher is required to effect the garnering of all valuable material. Many monthly, weekly, or daily publications of a literary or journalistic nature devote considerable space to scientific matters. Examples are found in the "Science and Invention" column of the *Literary Digest*, "Everybody's Business" in the *Saturday Evening Post* special sections, in the *Outlook*, *Independent*, *Pathfinder*, *Current Events*, Sunday school leaflets, and any number of other publications that circulate in the homes. These papers are often discarded on the arrival of a later issue and a number of clippings of an especially fine article can be secured. The daily and Sunday newspapers are a valuable source. (Madame Curie's recent visit stimulated a wealth of information in the news journals on scientific history and biography, radium, the growth of knowledge and other related topics.) Critical discussion of the articles brought in teach the pupil to value the newspaper as a chronicle of events in the scientific world, but to discredit the comments of the average reporter on these same events.

It is advisable to recognize and reward in some manner the

initiative shown by pupils in collecting clippings. This work of collecting and classification may be turned over to the "Information Committee" of the science organization, or to a group of the pupils who show a special bent for such work.

III. Classification and Filing

It is worse than useless, however, to collect material without filing it away in some systematic manner.

A regular filing cabinet and indexed cards is the best device, although a large pasteboard box with a lid can be arranged to serve the same purpose. Clippings may also be temporarily filed inside the covers of a large magazine such as the *Literary Digest*. This plan is especially convenient in making a rough preliminary classification. The covers can be given such labels as Heat, Light, Sound, Electricity, Radioactivity, Potash, etc. It is well to follow the same plan in filing away groups of articles for bulletin board display. All articles relating to a special topic such as *electrical resistance* or *chemical fertilizers* can be kept in one file until the class is studying the topic.

In addition to filing articles away topically, a reference index of the more useful ones should be kept on three-by-five or some more convenient-sized cards. This takes considerable supervision, but a well organized band of helpers greatly reduces the teacher's labor.

Card Catalogues

The table of contents and indexes of the books will give a fairly good basis for classifying the contained subject matter. The bulletins, etc., are also relatively easy to dispose of. A card catalogue system of topical reference, when once worked out for the school and public library supply of books, pamphlets, etc., remains a static, up-to-date unit. This is not the case, however, with the magazines. They pour in faster than the committees can classify their subject matter. Most of them contain no satisfactory table of contents. Few of them are dealt with in the Readers' Guide. If the material they offer is to be available when desired, they must be looked over page by page.

The *Popular Science Monthly* can be disposed of by utilizing the service sheets that are furnished on application. One of these service sheets can be posted on the bulletin board for the students to use. Another can be cut up into separate units and pasted directly on the cataloguing cards. The *National Geographic Bulletin* prints at the end of the school year a very complete

list of all articles published during the year. (This list, however, is not available during the current year.) Even if the other magazines contain a satisfactory table of contents— which most of them do not— the articles are of such unequal length and scientific worth that a descriptive catalogue of the home made variety is the only solution. It is, of course, comparatively easy to get a catalogue of the references in any special field. Two pupils at work on each magazine can usually card catalogue a special topic in one study period.

IV. Systematic Use of Material

Attention to Bulletin Board

No matter how varied and how interesting the magazines that are furnished, however, students show a tendency to read by "fits and starts" unless they are held down to some systematic p an. Some of them even disregard material posted on the bulletin board, unless their knowledge of it is checked up frequently. This checking up might very easily be done by means of true-false, completion, or matching tests. If a hectograph is used, the preparation, giving, and scoring of the tests would consume a minimum of time and effort.

Use of Magazines in Class Period

Systematic reading of the magazines can usually be secured if the work is socia ized to some degree. One or two class periods a month can very profitably be given over to reports and discussions of various articles that have appeared during the month. This feature of the work can be placed under the direction of the executive board of the science club, previously mentioned. Every month a committee of five or ten pupils may be appointed, each of whom is interested in some special field. The committee looks over the magazines as they come in and each member selects two or three articles which seem to him most significant in his special field. A list of the selected articles is posted and each pupil in the class is held responsible for a thorough perusal of two or more of them in addition to his voluntary reading. A class discussion as to whether or not the articles selected are really most worth while usually brings about a comparative discussion of related articles.

The program committee can occasionally allow the members of the class to make their own selections. Three or four days before the report period each pupil must have given the chairman of the committee the title of the article selected for report.

The chairman presides, calls for reports, and conducts discussions according to parliamentary procedure. The material presented in such reports should be of inherent interest to the student, and should be presented in an interesting manner to the class. The pupils may occasionally be required to take notes on the individual reports. These notes, which are collected and glanced over by the teacher, will be found to range from a summarizing topic statement to a fairly creditable outline of the reported article. Such exercises form a good test of the concentration of the individual pupils and, needless to say, the reporter is held strictly to account for a clear presentation of the central idea.

It is well to encourage a great deal of browsing during the first four or five weeks of the term, followed by frequent informal discussions of a volunteer nature. Some time during the second month each pupil in the eleventh and twelfth grade may be required to choose a topic in which he is especially interested, or may be assigned one if his special preference cannot be discovered.

Theme Work

It is undeniably difficult to get pupils of high school age to gather information regularly and methodically from a number of sources and finally, when the unorganized items have attained some volume, mould them in an organic whole. Their preference lies in the direction of reading a book or encyclopaedia article and then condensing it by copying every fourth or fifth sentence.

Special difficulty is therefore encountered in getting the pupil to glean part of his information from current magazines and part from different books, files of clippings, etc. If he has chosen a subject, however, in which he is really interested—one that is practically a hobby—his eight or nine months' search through magazines, bulletins, clippings, etc., the perusal of the various phases of his subject in well-written books, and even the final assembling of his ideas in well organized form will not be utter drudgery.

The final result should be an article or term paper of at least one thousand words which is to be criticised by the English teacher for sentence structure, technicalities, spelling, etc., and by the science teacher for accuracy and organization of subject matter.

Conference Periods

The pupil may need frequent "prodding" to keep him at his

task. Oral report sessions should be held at least once a month during which each pupil is required to report on information he has gained during the time. Some suggestions for additional sources of information will be offered by other pupils during these oral report sessions. The teacher can frequently make a suggestion concerning the relation any particular item reported on will have to the whole subject. Conference periods at least once a month should likewise be held. Individual conferences are always preferable, but if the teacher has too large classes or has no free period it may be necessary to hold conferences with a group of ten or twelve whose problems can be dealt with in group session.

Pupils will need some help in working out a logical treatment of the subject-matter and also considerable advice about note-taking. They can be trained to collect scattered bits of information on separate sheets, for instance, of a four-by-six scratch pad or convenient-sized card. They can also be helped to realize that these various scraps of information fall under one or another of the main topics of the subject.

Each student may be required to keep, on the regular library catalogue cards, a bibliography of his reference sources. He may frequently insist he is unable to find any magazine article on his special topic. If the subject has been wisely chosen, he can be shown that he simply has not looked carefully enough. He will, moreover, if extensive enough reference reading is required, acquire an increasing ability to glance over the pages of a book or magazine and isolate the matter pertinent to his field. The bibliography he has collected will, of course, help solve the teacher's problem of cataloguing reference material.

GLACIERS AT THE EQUATOR

We do not usually think of glaciers in connection with "darkest Africa" or any other part of that continent, but according to the United States Geological Survey, Department of the Interior, there are small glaciers on three of the highest mountains in Equatorial Africa—Mount Kilimanjaro, 19,321 feet high; Mount Ruwenzori, 16,800 feet high; and Mount Kenya, about 17,007 feet high. On Kebo Peak, which is a part of Mount Kilimanjaro, there is an ice cap 200 feet thick, which fills the ravines forming glaciers, several of which extend down to points 16,000 feet above sea level and one to 13,800 feet. Both Mount Ruwenzori and Mount Kenya are close to the equator, but their lowest glaciers extend down to points 12,700 and 14,460 feet, respectively, above sea level. A study of the moraines formed by these glaciers shows that during the Ice Age the glaciers were much larger than they are now.

PREPARATIONS OF THE METALS OF THE RARE EARTH GROUP

By H. C. Kremers

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The extreme electropositive character of the rare earths renders the preparation of the metals a difficult one. Their isolation is rendered still more difficult by the fact that the separation of the individual members from each other is no mean task. The rare earth ores are fairly abundant, especially those in which the cerium group predominates. In fact, in the incandescent mantle industry, thousands of tons of cerium group material are annually thrown away after the extraction of thorium from monazite sand. This enormous waste of rare earth material has been a great stimulus for research on the preparation of the metals.

There are in general two methods of attack in the isolation of the metals: Reduction chemically by metals more electropositive in character and electrolysis of fused salts.

The only metals which have been used more or less successfully for reduction chemically are sodium and potassium. The method has been partially successful and that only in the case of the less positive of the rare earths namely the yttrium group. The method usually used, was to mix the anhydrous chloride of the rare earths with the equivalent amount of granulated sodium, placing the mixture in an iron or nickel boat in an iron tube and allowing the reaction to take place under a high vacuum. The metal obtained as a fine powder is lixiviated with a large amount of water to dissolve away the sodium chloride, undecomposed chlorides and unused sodium. The metal powder can then be fused into a coherent state in a vacuum furnace. This method would, of course, hardly be applicable in a commercial way since, it would be far too expensive and slow, but it has been the means of making a study of some of the physical and chemical properties of the rare earth metals. Perhaps the greatest drawback to the method is the fact that the reaction of sodium and a rare earth chloride is a reversible one and that metallic sodium can very easily be prepared by the interaction of a rare earth metal and sodium chloride.

Electrolysis of the fused salts of the rare earths has been in commercial use for several years. This has, of course, only been applied to the production of cerium group metal or "misch metal." Several tons of misch metal have been made annually

in this country alone during the late war. Considerable use of this metal was made in igniters for hand grenades, tracer bullets and trench lighters. The raw material in the production of misch metal has always been the double sodium cerium group sulphates obtained as a by-product in the incandescent mantle processes. The waste liquors after the extraction of thorium are simply acidified with sulphuric acid and upon the addition of NaCl the double sodium cerium group sulphates will precipitate out. The double sulphates are then converted to the rare earth hydroxides by treatment with strong hot sodium hydroxide solution and the soluble sodium salts filtered off. The hydroxides are then converted to neutral chlorides, filtered to remove any rare earth phosphates that may have formed and dehydrated. The anhydrous chlorides are electrolized, using a cast iron pot as cathode and a graphite rod as anode. The melting point of the bath is usually sufficiently high to melt the misch metal as fast as it is formed. The melting point of misch metal is about 750°C, well below that of the melting point of the anhydrous chloride; the latter being about 950°C. It is thus evident that in the electrolysis of the fused chlorides of the cerium group or in general any of its members, the melting point of the metal being below or near that of its anhydrous chloride the metal is easily obtained in a coherent state. Excessively high temperatures of the bath are not necessary and there is very little volatilization of the latter. Considerable interest has been shown in the use of misch metal as a deoxidizer for cast iron, steel and other alloys requiring a scavenger to clean the molten metal of its dissolved oxygen. Misch metal has properties which make it quite desirable for this purpose: Melting point 750°C, heat of oxidation 1740 calories per gram and alloys with most metals are readily formed.

With respect to the yttrium group considerable more difficulty is encountered in the isolation of the mixed metal or any of its individual members. The metals are less electropositive it is true but the melting points are very much higher. Yttrium is reported as melting at 1250°C, erbium 1250°C and ytterbium as high as 1800°C although there is some doubt with respect to the latter. These high melting points are not the greatest evil to be overcome. Most of the anhydrous chlorides of the yttrium group have low melting points as compared with those of the cerium group. Yttrium chloride melts at 680°C, dysprosium chloride at 700°C and ytterbium chloride at 880°C. Thus

in the electrolysis of the fused chlorides of this group it is impossible to obtain the metal in the fused state and since the temperature of the bath must be maintained in the neighborhood of 1000°C there is a large loss of salt due to volatilization. It has been found that yttrium chloride is quite volatile slightly above its melting point.

Since the metals of the yttrium group are less electropositived than the cerium group and are also slightly less positive than aluminum it has been possible to prepare the mixed metals of this group by a solution of the oxides in a molten bath of cryolite and subjecting to electrolysis similar to that of the production of aluminum. It is, also, possible to use the double fluorides of the yttrium group instead of the cryolite. By these methods there is very little loss of any material due to volatilization.

It is quite probable that most of the rare earth metals as individuals will not command a great commercial use since the isolation of their salts is a very difficult matter. In summation then there are perhaps four metals of the rare earths which will find commercial use:

Cerium, which can be separated from the cerium group with considerable ease and has already been prepared and exhaustively studied.

Cerium free misch metal for which a demand will be created in time. The element cerium having two stages of oxidation is at times undesirable as a metal and cerium free misch metal would meet this difficulty.

Cerium group metal or misch metal which has found considerable use in pyphoric alloys as deoxidizers.

Yttrium group metal, slightly less electropositive in character but having a much higher melting point.

REMARKABLE REPTILES

While the clays that formed what geologists call the Morrison shale were being laid down in water in southern Colorado, there lived in that region many remarkable reptiles of huge size and great variety, According to the United States Geological Survey, Department of the Interior, many of these animals were mired in the soft clay of which the Morrison formation largely consists, and their bones, which are in places abundant, are now collected and studied by geologists. Some of these creatures, such as one knows as the Brontosaurus, were 60 feet long. Many of them had remarkably small heads, notably the Stegosaurus, whose diminutive brain suggests that it must have been very stupid. This animal was undoubtedly very clumsy also, but its huge size and its protective armor aided in its preservation.

CHEMISTRY AND THE STUDENT

By Adeline H. Jacobs

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On the opening day of each term, I meet for the first time one hundred girls—more or less—who constitute my chemistry classes for the ensuing year. These students, under my leadership, will become acquainted gradually with the equipment of the laboratory and the lecture-room, with the text-books and the reference library, and with the museum specimens of raw products and manufactured articles. Here, on the one hand, are the tools for acquiring mastery of the science; there, on the other hand, is plastic young womanhood, possessed of its varied abilities, interests and experiences. This living material is to be changed along definite lines; altered for all time in its responses to certain stimuli—in short, to be educated.

The process of education in chemistry involves the developing of special skills, the acquiring of a knowledge of the properties and transformations of matter together with the principles and laws pertaining thereto, and the attaining to an appreciation of the debt of humanity to the labors of chemists. All this is to be accomplished for the individual pupil and by the individual pupil. No mean task is this for the teacher of chemistry!

Elementary chemistry is largely descriptive. Elements and compounds are recognized by their behaviour and properties. The humorous definition "Chemistry is the study of smells" is not without significance. Results of experiments must be observed accurately, for the manual performance is not otherwise an exercise in chemistry. The mind must be active along with the hand. The observed phenomena must be brought into relationship with other knowledge. Having established the effect of acid on litmus, the student must be able to interpret similar results correctly.

Along with the processes of perception and of reasoning, we find that memorizing has a prominent place in dealing with the descriptions and generalizations of chemistry. As the subject develops from day to day, progress is possible only when facts are retained—a deposited fund against which the student can check. Valence of elements, and formulas must be constantly "on call" for the understanding of reactions. An almost overwhelming amount must be remembered, and remembered definitely and accurately, for gaining any satisfaction and pleasure from the science. But little of the letter-perfect mem-

orized material is to be remembered for life; nor will much of it stay with the pupil beyond the high school years. Yet this is not to be deplored, as there will be remembered the broader impressions—namely the fundamental idea of the indestructibility of matter; the relationship between cause and effect; the immutability of natural laws; the scientific basis of various household and industrial operations; and a general method of analysis for penetrating the complexities in any problem. A situation exists in chemistry to which responses must be made; but in post-school days, the *identical* situations may not arise many times again. How unlike the learning involved in arithmetic, where, for instance, the addition of the proverbial 2 and 2 presents a ***life-time*** situation to which must be made unfailingly the one correct response!

Scientific deductions are the result of reasoning. Observations of recurring chemical reactions lead the student to generalizations. Principles and laws are formulated from repeated phenomena. These principles and laws are then available for explaining newly arising conditions. The student is instructed in the preparation of nitric and hydrochloric acids; he learns the law controlling the selection of the contributing substances. Later the preparation of other acids, phosphoric, carbonic, etc., may be arrived at by following the rule.

At the very outset, the pupil should be led to appreciate that chemistry has extended the comforts and enjoyment of life. As an introduction to the subject, and referred to constantly throughout the term, is the thought that chemistry permeats all the arts and industries, in times of war and in times of peace. It is readily indicated how this basic science penetrates medicine and agriculture. It is fundamental to home-making, play-time and factory life. Some students will find that their life-work lies in the field of chemistry, either the pure or the applied science. Such girls realize that their high school chemistry will be directly useful if they contemplate becoming nurses, dietitians and laboratory-technicians.

How ennobling and stimulating is acquaintance with the biographies of the pioneers in chemistry. Youth is impressed by a recital of lofty ideals, perseverance in overcoming obstacles, by service to humanity. Personal ideas are raised by reading the lives of Pasteur, Madame Curie and other illustrious scientists.

The discoveries in chemistry would never have been made had the leaders lacked scientific imagination. Kekule describes very explicitly how he arrived at the explanation of the linkage of the carbon atoms in the "benzene ring," how after hours of contemplation, there flashed to his mind a picture of dancing gnomes, holding onto other dancing gnomes, whirling along. Thus his problem was solved. For a student to form usable, working images of atoms and molecules, he must project his imagination into the region of the infinitely small. This is a difficult process in these days when we think in terms of sky-scrapers, of transports carrying thousands of men, and of government loans counting up into the billions. Descriptions of mining operations and of manufacturing processes are encountered in chemistry. For a full concept, these should be pictured with the accompanying incessant activity and thundering noise of industry. Diagrams and photographs point the way. But in all cases the student's own imagination must be active in order to understand the real meaning of man's mastery over matter—the province of chemistry.

THE CARTESAN DIVER DROWNED

By B. C. Zimmerman

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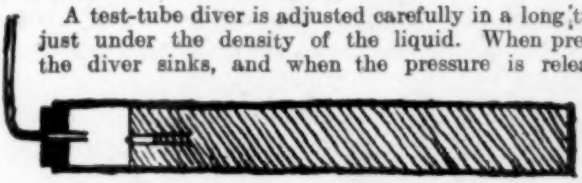
As the writer has not been able to locate any information on a drowning Cartesian Diver, he submits his "important" discovery to the readers of School Science and Mathematics.



A test-tube diver is adjusted carefully in a long tube to a density just under the density of the liquid. When pressure is applied, the diver sinks, and when the pressure is released, the diver will rise in the usual way, *provided a certain critical depth has not been exceeded,* in which case the diver will sink to the bottom and remain there. This critical depth is a function of the amount of air confined in the test-tube, not to mention the density of the liquid, temperature, etc. It may be defined as the depth at which the liquid pressure becomes great enough to reduce the volume of the air in the test-tube to such an extent as to make the density of the diver together with the confined air as great as the density of the liquid, irrespective of the pressure in excess of atmospheric applied at the surface of the liquid.

Instead of covering the long tube with a rubber membrane, a "delivery tube" is fitted into the top, in order that the diver may be rescued by the mere application of suction at this tube. In that case the experiment may be repeated indefinitely.

THE ORIGIN AND DEVELOPMENT OF ALGEBRA[1]

By Louis C. Karpinski

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The mathematical sciences furnish excellent illustrations of the process of evolution in the realm of thought. Particularly the development of algebra and algebraical analysis, having taken place largely within the times of historical records, offers to us the step by step unfolding and enlargement of a series of connected scientific ideas.

The earliest algebraical conceptions are doubtless those connected with an algebraical symbolism. The use of hieroglyphs, of ideograms, and the use of an alphabet are all more or less fundamentally related to the algebraical representation of mathematical concepts. The use of geometric forms in ancient civilizations to represent numbers and even symbols of operation among the Egyptians constitutes truly a great forward step in the progress of mathematics.

In Egypt is found the birth-place of many ideas, which in later times have determined the direction of mathematical progress. The domination of Egyptian science by practical needs, as intimated by Herodotus, has been widely accepted without scrutiny and without protest even by scientists and Egyptologists.[2] In truth the few records of Egyptian mathematical science which are preserved, by some kind accident of fate, furnish the most detailed and specific evidence of the cultivation of mathematics as a pure science by the Egyptians; further the Egyptian documents present a whole series of basic algebraical notions.

The Ahmes papyrus contains a section devoted to the solution of first-degree equations. "A heap (unknown, ahau) and its seventh makes 19," is the reading of one of these problems.

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[1]This paper appeared in French in the journal "*Scientia*," (*Rivista di Scienza*), XXVI, (1919), pp. 89-101. This journal, devoted to Scientific Synthesis, commonly prints English articles in the original language, together with French translation. However, war conditions resulted for a time in the suspension of this procedure. Permission to reprint in English is due to the courtesy of the editor, Dr. Eugenio Rignano.

[2]Recently Professor James H. Breasted of Chicago University, probably the foremost Egyptologist in the world, has found in an early Egyptian medical papyrus evidence of a purely scientific nature in medicine. Professor Breasted states:

"The current conclusion regarding the mind of the ancient Egyptian, a conclusion in which I have myself heretofore shared, has been that he was interested in scientific principles, if at all, solely because of the unavoidable necessity of applying them in practical life; that if he discussed the superficial content of a many-sided geometrical figure or the cubical content of a hemisphere it was because he was obliged to measure fields for taxation purposes and to compute the content of granaries. In the field of Egyptian mathematics Professor Karpinski of the University of Michigan has long insisted that the surviving mathematical papyri clearly demonstrate the Egyptians' scientific interest in pure mathematics for its own sake. I have now no doubt that Professor Karpinski is right, for the evidence of interest in pure science, as such, is perfectly conclusive in the Edwin Smith Medical Papyrus." In *Bulletin of the New York Historical Society*, April, 1922, p. 29; article entitled "The Edwin Smith Papyrus."

The process of solution is definite and complete, arriving at the root 16 ½ ⅛, and is applicable to any equation of the first degree in one unknown. A series of more complicated problems follows, each with complete solution. For any practical application of these problems, for any physical need which suggested such problems, the student will seek in vain. The process of solution, leading certainly to the root, is a notable step in real science.

To justify our recognition of the ahau-problems of the Ahmes papyrus as marking progress in science Egyptian documents found at Kahun and Illahun give to us a logical continuation in simultaneous quadratic equations, leading to pure quadratics of the type, $ax^2 = n^2$, again with a complete process of solution. It is worthy of note that this quadratic arises from the consideration of a problem in geometry, which is to distribute an area of one hundred square units into two squares whose side have to each other a given ratio. Again and again in the historical development we shall see that analysis has received new inspiration and new life by the stimulus of geometrical methods, notably in the invention of the analytical geometry and in the developments with complex numbers.

The mathematical ideas associated with series of numbers formed according to law are fundamental in modern mathematics and likewise in ancient mathematics. In the Egyptian manual problems on arithmetical progressions present the terminology, which we continue to employ, and indicate even that, in some mysterious manner, the Egyptians were familiar with an equivalent of our analytical solution by formula of problems connected with such series. Thus the problem is given to divide one hundred loaves of bread according to the terms of an arithmetical progression among five people in such a way that one-seventh of what the last three have is equal to what the first two have. Taking a, $a+d$, $a+2d$, $a+3d$, and $a+4d$, as the terms, we would obtain $d = 5\frac{1}{2}a$; this would give by summation $60a$ as 100, and a as $1\frac{2}{3}$. The Egyptian reckoner assumes a as 1, and without comment or explanation, takes $5\frac{1}{2}$ as d; finding the sum of this series, 1, $6\frac{1}{2}$, 12, $17\frac{1}{2}$, 23, to be 60, instead of 100, each number involved is increased by $\frac{2}{3}$ of itself and thus the solution is obtained. Were this a single, isolated problem it would suggest the possibility of advanced mathematical attainments on the part of the Egyptian scientists. As one of several problems bringing many and noteworthy and

fundamental ideas concerning series to light the solution must be regarded as something more than fortuitous.

In other problems the arithmetical mean appears, together with the common difference and sum, in a solution which again parallels closely a solution in modern symbolism. Naturally no symbolism comparable to that of our literal algebra appear, and one could hardly hope to find fifteen hundred years before Christ these ideas which appeared in Europe with Viète more than fifteen hundred years after Christ.

The single illustration in the manual of a geometrical series confirms and supports the implications of high attainments in algebraical thinking. The summation of the geometrical series, 7, 49, 343, 2401, 16807, is effected both by actual summation and by multiplication in Egyptian style of 2801 by 7:

2801	1
5602	2
11204	4
19607	

The modern formula for the sum of this series gives, $7\,\frac{7^5-1}{7-1}$, or 7 times 2801. Is this again accidental coincidence?[3]

Leonard of Pisa, three thousand years after Ahmes, includes this series of powers of seven, but with one further term, in his *Liber Abbaci;* he effects the solution precisely in the two ways given by his Egyptian predecessor.

In Babylon, too, the arithmetical and geometrical series received special consideration. Details of their methods of treatment are not yet available, but the moon-tablets deciphered by Hincks, involve the terms of a geometrical series with ratio 2 and ten terms of an arithmetical series with 16 as common difference. Powers of two, including the fractions which are negative powers, are fundamental in the Egyptian scheme of multiplication by repeated doubling, illustrated above, and in the reverse operation of division. Iamblichus ascribes a Babylonian origin to the harmonical series, but confirmatory tablets are not yet available.

Squares and cubes and powers of integers have played and continue to play a large rôle in mathematical analysis. Tables

[3]Recently at the 1922 summer meeting of the Mathematical Association of America, Professor R. C. Archibald of Brown University called attention to the fact that a Russian journal published some years ago a translation of an early Egyptian document containing, in effect, the formula for the volume of a truncated pyramid. This is in entire harmony with the developments which I have mentioned.

of squares and cubes are found in Babylon, while in Egyptian documents the relation $3^2+4^2 = 5^2$ appears, and is used, frequently. The sequence of powers of 60, and of powers of 1/60 constitute the vital feature of the Babylonian system of numeration, but the recognition of the mathematical significance of these ideas extended evidently far beyond the simple application of numeration.

Mathematical tables are of such importance that it is worthy of note that the Egyptian manual opens with a table of reference, for converting fractions with numerators 2 (and above, probably) to unit fractions. The Babylonians had not only the tables mentioned above but also extensive multiplication and division tables.

Today the dependence of early Greek science upon Egyptian and Babylonian foundations is generally recognized, but the extent of the indebtedness particularly as regards the directive force of the earlier work is frequently underestimated. Along analytical lines the Greeks continued the Oriental studies in series, continued the work on linear and quadratic equations but in geometrical garb, continued the work on squares, cubes, and powers, and continued and extended the applications of the Pythagorean theorem, arithmetically as well as geometrically.

The "application of areas," one of the fundamental processes of early Greek geometry, is essentially an algebraical process. To apply a given area to a given line, within a given angle, Euclid I, 44, is simply to solve $ax = k^2$, taking the given area as a square and the given angle as a right angle, both for simplicity but not affecting the problem. The Greek considered this then simply as finding the unknown side of a rectangle when one side and the area were given. Similarly the application of a given area to a given line, within a given angle and exceeding or deficient by a square (for simplicity), gives the solution of the algebraical problems.

$ax+x^2 = k^2$, and,

$ax-x^2 = k^2$, or the complete quadratic.

The insertion of the geometric mean is the geometrical solution of the pure quadratic, $x^2 = ab$. The whole of the second book of Euclid and much of the fifth are algebraical, and directly related to the work which we continue to do in elementary algebra. Masters of Greek mathematical science like Heath, Tannery, Zeuthen, and Loria have long been teaching these facts of the Greek geometry.

With Hero of Alexandria and with Diophantos algebra frees itself in Greece from the geometrical clothing. The analysis of the ancient world continued to exert influence, through these two writers in particular, during the middle ages; the problems of Diophantos and of Apollonius connect the modern mathematics of Descartes and Fermat and Newton directly with the old science, for the work of these modern masters had a starting point in the problems of the Greeks.

In the mathematics of ancient India, as given in the rules for altar construction, there are many points of similarity with the Greek theorems connected with the Pythagorean proposition; particularly the arithmetical side appealed to the Hindus and we find there further very good approximations for the square root of 2, the diagonal of a unit square. Noteworthy and significant are the algebraical developments in India between the sixth and the eleventh centuries. Aryabhatta of the fifth century, A. D., Brahmagupta of the sixth, Mahaviracarya of the ninth, and Bhaskara of the eleventh, made real progress along the lines of the algebraical formulation and solution of problems, including the solution of complete quadratics.

Among the additions made by the Hindus, aside from the matter of symbolism, which included also symbols for negative quantities, may be mentioned the use of the second differences in series, the summation of the series 1, 3, 6, 10, $n(n+1)$, and the summation of the series (mixed) of square numbers. The complete solution in integers of indeterminate reasoning equations, both of the type $ax+by = c$, and the far more difficult $ax^2-by^2 = c$ was effected by methods requiring a most refined type of mathematical reasoning. Hankel long ago pointed out that these Hindu methods represent the finest achievements in number theory before Lagrange. Indeed the methods of the Hindus were rediscovered by Lagrange and Euler and other European mathematicians of the first rank.

Some would ascribe this advance to direct Greek influence on the Hindus; in the absence of any similar development in Greek mathematics reference is made to the possibility of such theories in the lost books of Diophantos. The evidence of the Hindu origin is internal, as well as external, since the contributions of the Hindus fit together like the wheels of a watch, making a consistent whole. The tendency of many writers to depreciate the attainments of the Egyptians, Babylonians, Hindus, and the Arabs is due to a fundamental misconception of the nature of science.

Intellectual development, including the creation of science and art and literature, is not local. Science today is not limited by any means to the Germans, nor to the Europeans nor contributions of real value to the Indo-Germans, nor in the past was it limited to Greeks. Science is universal, a product of that intellect which distinguishes man from beast.

Another characteristic contribution of India to analysis is the sine function employing the half-chord in numerical computations involving the circle, instead of the whole chord of the Greeks. The genius of the Hindu for computation, for the numerical treatment of mathematical concepts, prompted this departure from Greek usage, for the whole chord is not suited to extensive computations. In the hands of the Arabs, who had the gift of systematization, this change made possible the reduction of trigonometry to a school discipline, within the comprehension of ordinary individuals, and made possible, also, those simplifications encountered in the wide applications of the trigonometric relations.

The achievements of the Greeks and of the Hindus were assimilated by the Arabs. Combining the science of pure reasoning with the art of computation, systematizing and enlarging the combination, the Arabs made themselves the master scientists of the world for a period of more than half a millenium. Frequently science as developed under the patronage of the caliphs has been regarded as entirely lacking in originality, the service which was rendered by this civilization as simply that of transmission of the work of others. In science as in life there is no middle ground between progress and decay. The intellect which could appreciate and acquire the diverse sciences of the Aegean Sea and the Ganges River was able under the double inspiration to make notable contributions of its own. The comparatively few available Arabic scientific documents well attest the originality of the Arabic contribution.

The first systematic treatise on algebra is the work of the great Arab, Mohammed ibn Musa al-Khowarizmi; his patronimic is preserved in our word "algorism" by which name our present system of arithmetic was long designated in Europe. The word "algebra" is a part of the title, al-jebr w'al-muqabala, of his treatise on this subject; two other words, "zero" and "cipher,' trace their origin directly to his works. The algebra of Al-Khowarizmi is not the simple translation of any Hindu

work; rather it is the work of a scientist who has profited both by his study of Greek and Hindu mathematics. In content it presages much of our modern algebra. Solutions are given of the six types of quadratic equations (one linear),

$$ax^2 = bx,\ ax^2 = n,\ bx = n,$$
$$ax^2+bx = n,\ ax^2+n = bx,\ ax^2 = bx+n.$$

The word "algebra," meaning "restoration," refers to the transference of the negative term in an equation; thus the operation of changing $x^2-10x = 21$ to $x^2 = 10x+21$ is the operation of "algebra," the x^2 being regarded as incomplete of an amount $10x$, which is restored to it by the process. Complete recognition of positive and negative quantities, with the single type form of quadratic, $ax^2+bx+c = 0$, did not come until after Viète. The problems are always given, of course, with numerical coefficients; the analytical procedure of the solution for each type would apply to any problem of the type. To the analytical solution is added a proof by a geometrical figure involving propositions largely of the second book of Euclid.

In the "liber algebra et almucabala" there is work on the product of different types of binomials and also work on quadratic surds, both corresponding to phases of our elementary algebra. Al-Khowarizmi himself applies algebraical methods to the solution of geometrical problems; later Regiomontanus applied the "ars rei et census," as the methods taught by the Arabs were designated, to the solution of trigonometrical problems.

Any study of early European texts on algebra reveals how continuous and how direct was the influence on Al-Khowarizmi for nearly seven hundred years.

The part which the Arabs played in the popularization of the study of algebra is well illustrated by the treatise of Abu Kamil, written about a century later than that of Mohammed ibn Musa. Abu Kamil's work was the subject of at least two Arabic commentaries in the tenth century; a translation was made of the work into Latin, and probably into Spanish; as late as 1450 a Hebrew translation and commentary was prepared by Mordechai Finzi of Mantua, so that for more than five hundred years this treatise was in active use. Surely this book may be regarded as an important document in the history of learning.

Among the great Arabic algebraists is one whose name and fame, but not in science, are widely known, Omar al-Khayyam.

His just title to a place among the great in science is as well established as is his place among the poets. The algebra of Omar al-Khayyam, published in 1851 by F. Woepcke, systematizes the problems connected with the cubic and achieves the solution by the intersection of two conics. Archimedes appears to have achieved the solution of one type of cubic by conics, and a number of Arabs before Omar were stimulated to a study of the problem of Archimedes, to cut a sphere into two segments which should have to each other a given ratio. The Archimedean solution is lost, and it is not even certain that the indications of his method as given by Eutocius were known to the Arabs. In any event they generalized the solution, and definitely related it to other types of cubics. Even the trisection of an angle was recognized by Al-Biruni (1000 A. D.) as the equivalent of the solution of a cubic.

The Diophantine type of algebraical analysis was continued by Al-Karkhi in his "fakhri;" noteworthy extensions were made to indeterminates of higher degree. Ibn Haitham (c. 960-1025 A. D.) gave the summation of the fourth powers of the integers, as well as of the squares and the cubes; this he gives incidentally in connection with a highly refined solution of the problem of determining the volumes obtained by rotating a parabolic segment about any diameter, and also about an ordinate.

The first systematic treatise on plane trigonometery was made by Nasir ad-Din at-Tusi (1201-1276 A. D.). Europeans became familiar with the materials and the methods of this work through the trigonometry of Regiomontanus, *De triangulis ommis modis libri quinque*, but only recently has the indebtedness to Arabic sources received recognition.

The dissemination of knowledge by the Arabs is no mean portion of their contributon to Western civilization. Adelard of Bath and Michael the Scot, John of Spain, Gerhard of Cremona and Plato of Tivoli, and Hermann the Dalmatian are representative of the translators of Arabic works of science; Alexandre de Ville Dieu, John of Halifax (Sacrobosco), Leonard of Pisa, and Regiomontanus popularized the Arabic teachings in mathematics. Widespread interest in science appears to be a somewhat necessary requisite for progress; in the multitude of students there is strength, inspiration, the basis for building, and the greater chance for the appearance of exceptional students.

The period from 1100 A. D. to 1500 A. D. is commonly regarded as quite unfruitful in mathematical developments

particularly in Europe. However this period in Europe is worthy of more attention than it has received because during this time we have the extensive popularization of the mathematical sciences which made possible the developments of the sixteenth and seventeenth centuries. The diffusion of the science of the Arabs, the universities with their multitude of students, and the Crusades with the broader outlook which they gave to the fortunate survivors, all contributed in the revival of learning on a larger and more inclusive scale than ever before. The printing press came to serve by quantity production of the newly discovered intellectual needs of the masses.

The study of arithmetic and algebra, of astronomy and trigonometry, was common in European countries during the twelfth to the sixteenth centuries. In Italy the devotees of algebra were numerous and continuous from the days of Leonard of Pisa to the days of Cardan and Tartaglia. Many of the treatises of this period have disappeared; this seems to be the fate of a work on algebra by William of Luna, an Italian translator of Arabic works whose activity falls early in the fourteenth century. Probably many works are still to be found in the libraries of Italy; thus at Florence, in the Biblioteca Nazionale, is to be found the fifteenth century work by Raffaello di Giovanni Canacci, and at Siena, *Biblioteca Comunale*, is to be found a fifteenth century compendium on algebra which lists a whole series of workers in this field of study.

The cultivation of algebra almost as a school discipline in Italy had its fruit in the beginning of the sixteenth century in the complete solution of the cubic by Scipione del Ferro, and Tartaglia. The logical continuation in the algebraic solution of the biquadratic, made by Luigi Ferrari, an able pupil of Cardan, marks the end of the straight route in algebra.

The impossibility of the general, algebraical solution of equations of degree higher than the fourth, and the conditions under which such equations are solvable, became the subjects of fruitful speculation, culminating in the definite solution of the problem in the early nineteenth century. The young Norwegian Niels Henrik Abel (1802-1829) proved in 1824 that the general quintic and equations of higher degree are not solvable. The young Frenchman Evariste Galois (1811-1832) elucidated the conditions necessary for the algebraic solution of a given equation, and began the important work of the application of the theory of groups to the theory of equations.

Some progress in the direction of the achievements of both Abel and Galois had been made by the Italian, Paolo Ruffini (1765-1822). Only a little before the birth of Abel, Gauss had demonstrated the fundamental theory of algebra, that every equation has a root.

The introduction of literal coefficients was, of course, a necessary preliminary to the work on the theory of algebraical equations which is described above. Leonard of Pisa and Jordanus Nemorarius in the thirteenth century, appeared to be on the brink of this discovery, but they lacked suitable symbols of operation which would render it possible to express the interdependence of a series of functions of the same quantities; by them new letters are constantly brought in to express combinations of the old. The subsequent development of algebraical symbolism for the operations made it possible for Viète, towards the end of the sixteenth century, to give a fairly complete literal notation for knowns and unknowns.

The developments made by Viète connect very directly with the invention in the first half of the seventeenth century of the analytical geometry by Descantes and Fermat. In this application of algebrical methods to the solution of geometrical problems the algebra profited quite as much as the geometry. Negative quantities receive almost immediately their full recognition; a century and a half later the complex number diagram was discovered, establishing the complete number system of algebra as acceptable to even the most skeptical. This complex diagram was the work of a Norwegian Kasper Wessel, but it was also discovered independently by Gauss and Argand. The application of the complex numbers in the theory of algebra was well begun by Gauss, and continues to the present day.

The numerical side of the solution of equations deserves brief mention. Leonard of Pisa gave the value of the real root, in sexagesimal fractions, of the equation $x^3+2x^2+10x = 20$, with an accuracy equal to that of ten significant figures in decimal notation. Unfortunately his method is not known. The method of Charles Sturm (1803-1855) enables the complete determination of the location of the real roots; the methods of Viète, Newton, and Lagrange, and the methods of the Chinese, of Ruffini and Horner, permit the computation of the root to any desired degree of accuracy. Cauchy (1789-1857) determined the method of locating the complex roots from equations, completing the work of his compatriot.

Essential harmony exists between the universe of numbers and the universe of form, between algebra and geometry. Those problems which are geometrically solvable with ruler and compass correspond to algebraical problems which are solvable with linear and quadratic equations in terms of no other than quadratic irrationalities. In the analytical geometry the equation of the first degree in two variables corresponds to the geometrical straight line; to the circle corresponds a particularly simple type of quadratic equation, $x^2+y^2 = r^2$, and to other conic sections correspond other equations of the second degree. Klein applies the icosahedron to simplify the discussion of the problems connected with the general equation of the fifth degree. In the graphical representation of complex numbers we find that the roots of $x^3-1 = 0$ when plotted give the vertices of an equilateral triangle, the roots of $x^4-1 = 0$ give the vertices of a square, the roots of $x^5-1 = 0$ give the vertices of the regular pentagon; any regular polygon of n sides can be constructed corresponds to an equation $x^n-1 = 0$ which is solvable in terms of quadratic irrationalities. Gauss showed that the regular polygon of seventeen sides is constructable with ruler and compass by solving the equation $x^{17}-1 = 0$. With Abel these equations achieved fundamental importance in the general theory of algebraical equations.

The development of algebra as it has been outlined most briefly, for such a long story, is not to be thought of as something apart from the general progress of mathematical science as a whole. Science is essentially a unit, continuous throughout the ages, the creation of the great mass of its devotees of all times and of all nations.

TANGENT LINES AGAIN

By Florian Cajori

University of California, Berkeley

Professor G. A. Miller states in his article on page 715 of volume XII that I did not understand the nature of his criticism of a passage on page 163 of my *History of Mathematics*. I admit that I apparently misunderstood him; I thought that he had reference to tangents at singular points of curves. This failure is really to my credit, for the reason that Professor Miller, in his last article, injects into our controversy a foreign topic, namely, the consideration of secants of a kind that have no closer relation to the paragraph referred to in my history

than has the cosine of Noah's Ark. His brilliant three pages on secants "have nothing to do with the case." The question discussed in that paragraph of my history deals with the nature of the contact that a tangent has with a curve at the point of tangency. The Greek idea that at that place the tangent and curve have only one point in common was contrasted with the conceptions of later mathematicians. The ordinary secant has no place in this comparison. Professor Miller is misled by his consideration of only a fragment of a sentence, which he quotes from my history. He is too near-sighted and puts an interpretation upon this fragment which makes nonsense out of the entire sentence and of the paragraph in which it occurs. I supposed that if there are two ways of interpreting a passage, one interpretation making sense and the other interpretation making nonsense, that the author was entitled to the interpretation that makes sense. The well-known logician of mathematics, Professor Keyser, says in his admirable book, *Mathematical Philosophy*, page 255, when eludicating a point: "Here as elsewhere, it is essential to use good sense." (Neither Keyser nor I attach to these words an odious meaning.) It is not good sense to insist on a ridiculous interpretation when a sane interpretation stands out in full view.

It seems strange that my critic should take such great pains to point out what he considers errors in the writings of others, and himself should take such little pains always to observe absolute precision. For example, he translates Chasles' definition of the tangent to a curve as "a line which, having a point in common with the curve is such that one cannot draw through this point any other line between this one and the curve." Professor Miller says "line" where Chasles says "droite" (straight line). When editors of Euclid mean "straight line," they say "straight line." That the word "line" has other meanings in mathematics is evident from Newton's *Enumeratio linearum tertii ordinis* (enumeration of lines of the third order).

The reader of Chasles' definition in French will get the meaning instantly. The reader of the above translation may hesitate an instant and may consider the hypothesis of "straight line;" he will find it fit and will accept it. He may test the hypothesis of "curved line;" he will find it unfit and will reject it.

However, a reader who is *a critic, disinclined to observe Keyser's caution on the "use of good sense,"* might go to print with the statement that the hypothesis "curved line" is *not* excluded

from Chasles' definition as translated above, that accordingly any number of "lines" may be drawn through the point of tangency between the tangent and the curve. With restrained emphasis this critic might then dwell upon the absurdities which can be deduced from this. The critic might also assume it to be his duty, as a scientific man, to inform the public of his belief that these absurdities furnish evidence of a regrettable incompetency of the writer, whom he is criticizing, to deal with fundamental questions of mathematics!

BETTERMENT OF SCIENCE TEACHING

By Herbert Brownell

University of Nebraska, Lincoln.

In an attendance upon meetings of science teachers through many years, the writer fails to recall more than a scattering few discussions concerning a teacher-supply for the smaller high schools [1] whereby in them year after year science instruction of high degree of excellence might reasonably be expected. Almost without exception such discussions were half-hearted and wholly inadequate. It would seem quite worth the while of leaders zealous for the promotion of science teaching to give consideration to the system long in vogue for certification of teachers. From this consideration it would seem very proper to exclude the science teachers who are products of teacher-training institutions.

It might easily be a revelation to many an "educator" to himself take one of the examinations whereby a "License To Teach" any and all secondary school branches, including science subjects, may be had—a license which in due time becomes a Life Certificate. Apart from ability to get a "grade" of 75% more or less in answering a certain ten or more questions per subject, and apart from a certain lottery characteristic in the choice of these questions, by what stretch of the imagination could any such examination be deemed a suitable test of a candidate's knowledge of any science beyond a mere mastery of statements readily attained by diligent processes of cramming.

Then, too, apart from various other considerations unnecessary of mention here, let it be considered where, in the continued use of the time-honored "Examinations for Teachers' Cer-

[1] Of the 16,000 and more public high schools in the United States approximately one-fourth of them have 25 pupils, or less; one-half of them, 50 pupils, or less; two-thirds of them, 75 pupils, or less. Less than 5% of these schools have enrollments exceeding 500 pupils.—[Bulletin No. 19 (1920); Bureau of Education.

tificates," there will be discovered in any candidate evidence of teaching skill and aptitude, of ability to reach decisions quickly and justly, of any mastery of teaching principles and teaching procedure, of any wide outreach in general knowledge and in human interests distinguishing the teacher from a mere hearer of recitations. All this is an old story and a discouraging situation for school officials and educators solicitous as they are for a better level of instructional fitness and capability.

What shall be the part of science teachers as individuals and as organizations in the solution of this teacher-problem! How may science teachers in service align themselves so as actively to promote existing teacher-training agencies, and whatsoever else gives promise of a betterment of secondary science teaching! How may aid be rendered in promoting a teaching fitness whereby is attained the ends for which science subjects are put into the curricula of secondary schools!

In gatherings of science teachers not a little of weariness sometimes attends discussions of the relative merits of the "tweedle-dee" and "tweedle-dum" of scientific effort and achievement when at the same time one is painfully conscious that an enthusiastic leadership continues indifferent to an all too prevalent teaching inefficiency among that great silent majority of high school science teachers unrepresented in these meetings.

It is not the purpose of this paper to deride the granting of teachers' certificates on the basis of grades attained by examination. The question is rather one of the betterment of a plan long in use not because it has been a satisfactory testing of teaching worth and fitness but because nothing better was at hand which was workable. Notable advancements have been made in school organization and school administration, in school buildings and equipment, and in all the varied agencies promoting the welfare of pupils. No sufficient advancement has been made as regards any far-reaching plan to license individuals manifestly fitted for teaching by reason of personal characteristics, both natural and acquired, as well as by scholarship and morals—a deplorable lack of progress in an age of advancement in all that pertains to public education. It is axiomatic that as the teacher is, so is the school. All progress in other respects fails of its full fruitage without competent instructors. The problem of schools primarily is ever one of the human element embodied in pupil and teacher. Nowhere is this more true than in the teaching of science in secondary schools.

The worth of educational measurements, and of the various mental tests devised to determine readiness of responses and definiteness of knowledge, a species of examinations though these may be, requires no discussion here. Through them is determined more or less satisfactorily the fitness of individuals for special lines of business and professional endeavor, for promotions in schools and for entrance to college. Why not turn aside from some of the endless testings of hapless pupils, and from the burden imposed on long suffering teachers in checking up the results of mental tests in reading, spelling, or other branches whereby some would-be educator may derive needed data for a Master's Thesis, *and test out teacher-candidates in that broad field of general intellectual capacity and special teaching fitness which is wholly apart from "knowledge gained of books."* Let such tests for teachers' certificates seek among other things to determine the definiteness and usableness of a candidate's all-around knowledge of life affairs and life situations, of human nature and its control—evidences of fitness for teaching "folks" as distinguished from teaching subjects. A just criticism of school work generally, and not less in science than in other teaching, concerns itself with the subordination in school work of efforts for making men and women of worth and character to an exaltation of "grades" in various intellectual stunts.

What constitutes a great teacher? From among the crowd of aspirants for certificates to teach, how proceed to discover those who possess qualities which time and experience will ripen into greatness in teaching worth and ability? The present system of examination for certification in and of itself certainly offers little of hopefulness for gathering together those "choice spirits" capable of inspiring youth to the best in manhood and womanhood among whom, it may be, are some who lack coveted college degrees and honors. In the present system is small hindrance to certification for teaching service of those whose natural inaptitude enables little more hopeful than time-serving. That this service by reason of their own volition is commonly short in no wise lessens the indictment lodged against a system of certification whereby the manifestly unfit can so readily get into the teaching service. That so much of efficiency and of superior teaching fitness is in evidence in the public school service may be considered an incident to, rather than the result of the system followed in certification of teachers. To devise and put into operation, both in and out of teacher-training institutions,

a system employing the best which has been attained in mental measurements and in educational tests constitutes a "problem" not alone attractive but in and of itself a challenge. The interests of science teaching demand that it be solved. Let teachers of science aid in its solution.

COMPRESSED AIR FOR THE LABORATORY

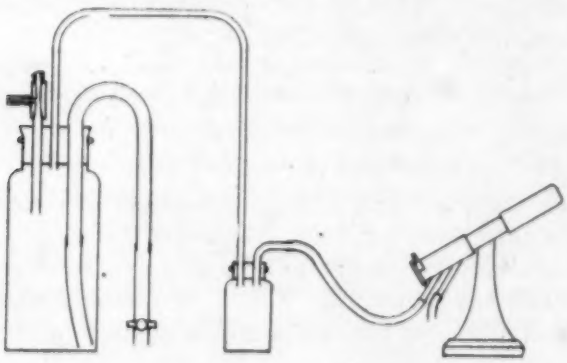
By H. J. Wing

High School, Columbus, Nebr.

Every teacher of science will find that the knowledge of the operation of a blast lamp will be very useful. By using the blast lamp many experiments otherwise impossible may be performed. Repairs to broken glassware may often be made and many small pieces such as "T" tubes, side delivery test-tubes and others may be made at a considerable saving of time and expense. Instruction in the art of glass manipulation will often give an added interest to laboratory work.

However, a blast lamp is of no use without some source of compressed air. A bellows may be used and there are many good forms on the market. However, the use of a bellows distracts one from the business at hand besides involving some little labor. In larger institutions a power pump which supplies air to all laboratories may profitably be used.

In any high school supplied with running water, a convenient source is at hand. The utilization of an aspirator as a source of compressed air may be a new idea to most of the readers of this article. However the idea was suggested in a small book on glass blowing, published in England, the name and author of which I have forgotten. Following out this suggestion I devised and am at present using the apparatus shown diagramatically in the accompanying sketch.



An aspirator in operation draws air through the side tube. If this entrained air is trapped in a bottle with a delivery tube for the air and a suitable outlet for the water, pressures of from 1 ½ to 3 pounds per square inch may be obtained, using an ordinary city water supply. This pressure is sufficient for practically all lamps sold for laboratory purposes.

For the trapping bottle, the largest, wide-mouth, reagent bottle obtainable should be used. The taller the bottle the better the operation of the device. The outlet tube of the aspirator is fitted through one hole. The aspirator should be of the largest size obtainable. The delivery tube for the air, which should reach a foot or more above the bottle so as to avoid as much as possible any forcing over of water, is fitted to one of the other holes. The third hole, which should be larger than the others, is fitted with a piece of 3/8 inch glass tubing bent as shown. The end of this tube inside the bottle is fitted with a short piece of rubber tubing. By bending this into the angle between the side and bottom of the bottle, the escape of air bubbles through this tube may be largely avoided. A piece of tubing long enough to bring the outlet to the drain is fitted to the other end of this bent tube. The amount of water and the velocity with which it escapes from the bottle is regulated by a screw clamp on this outside rubber tube.

In order to prevent any water from getting into the air line a safety bottle is inserted as shown. Be sure that all joints are tight.

In operation the aspirator is attached to any convenient water tap. The pressure at the delivery end may be regulated by the amount of water used, by the speed with which it is allowed to escape from the bottle and by a screw clamp or gas valve in the delivery line. After the first regulation for delivering maximum pressure, the entire regulation may be made by the screw clamp in the delivery line.

STEPHEN GRAY'S PARABOLIC MIRROR

By E. H. Johnson

Kenyon College, Gambier, Ohio

Readers of the article in the December issue of School Science and Mathematics on "A Fifty-foot Mercury Telescope" may be interested in a far earlier suggestion for making a concave reflector of variable curvature. In Vol. XIX of the *Philosophical Transactions* (1697), No. 235, Stephen Gray gave a brief account

of some preliminary experiments which had led him to think that it might not be impossible to construct a parabolic mirror by the simple suspension of a flexible sheet. His own words make his proposed method quite clear. He says, in part, as follows:

"A linen cloth being first wet in fair water, and then laid on a concave cylinder, as the verge of a sieve, or the like, its central parts will descend, so as to form a very regular concave superficies, which I suspected to be parabolical, well-known to be the best of figures, could it be obtained for burning glasses, in which I was not greatly deceived."

That he was approximately correct in this assumption was shown by the test he proceeded to apply, for he found the surface to be parabolic in section within the limits of the crude methods at his disposal. He did not mention the catenary. Of his test he said:

"A thread, being first wet in common water, and then suspended with its two ends, or any two points nearer than their utmost extent; so as to touch the center of the suspended cloth, and its two opposite points on the ring, was found to have the same curvature: as indeed could scarcely be doubted, since the cloth is but a number of threads suspended in the position of this single one. To discover the figure of the thread; thus suspended, I described parabolas of several species, whose axes were perpendicular, and parameter horizontal, to which the line being applied so as to touch the vertex, it passed very nearly through all the intermediate points of the parabola, much nearer than the portion of a circle, which passed through the extremity of the parameter and latus rectum, would do."

Having made these tests, Gray turned at once to the object he had in mind, namely the construction of a parabolic reflector, and apparently he was quite aware of the more obvious difficulties to be overcome. The idea of obtaining a variable focal length was especially attractive. We read further:

"Hence I conclude, that a ponderous and pliable substance, being suspended on a ring or hollow cylinder, so that its central parts may descend, will form itself into a figure that is more commodious for burning-glasses than the spherical, of which they are now made, being much nearer their most absolute figure, the parabola."

Now, if a way could be found to give the cloth, or leather, a metalline surface, or a varnish that may bear a good polish; or if this be found impracticable, perhaps plates of metal may

be beat out so thin, as being suspended on a large ring, will by their own gravity receive their true figure; speculums may be made of any size. And there will be another convenient property in them, that one and the same speculum will be changeable into all degrees of concavity, and so have its focal length increased or diminished, according to the purpose it is designed for."

He also tried experiments with heavier substances, such as thin sheets of potter's clay which were shaped by suspension and after drying were burned and glazed in the furnace, thereby rendering them rigid so that although the variable feature was sacrificed, he hoped the method would enable him to prepare a parabolic surface with a minimum of labor. These experiments, however, involved new difficulties, such that even if the surface had been given a high degree of reflective power, the optical inaccuracies involved would have made it quite worthless. Gray thought he was dealing with a true parabola. Apparently he did not know that although the catenary may approach the parabola in form, these curves are quite distinct, so that the surface his method was furnishing, even if it could be made ideally perfect, would not meet the optical requirements. Although his surface possessed errors which were prohibitd, it did not have some of the features which at present threaten to render the mercury reflector almost equally useless.

AN ELECTRIC FURNACE FOR LECTURE DEMONSTRATIONS

By Walter O. Walker

High School, Carthage, Missouri

Sometime ago the attention of the writer was called to a simple type of electric furnace. Mr. Walter Arthur, formerly research chemist with the General Electric Company, spoke of the ease with which an electric furnace of simple type could be constructed. Acting upon this suggestion, the writer has developed the demonstration furnace described below:

Essentially, the furnace consists of a graphite crucible (about 4″x3″) which acts as the negative terminal, and a carbon rod which acts as the positive terminal. Connections are made, through proper resistance, to a 220 D. C. line or any source of high amperage current.

The crucible is placed on a copper plate which in turn is connected to the negative terminal. The carbon rod is attached to the postive terminal. The rod is held in place by a burette clamp. The rod may be insulated from the metal clamp by

several layers of asbestos placed between the jaws of the clamp. The clamp is attached to an iron rod which in turn is screwed fast into an asbestos-covered piece of 4x8 board, which acts as the foundation for the entire apparatus.

The entire furnace (minus resistance, which can be located at any convenient distance) is very compact and need only weigh a few pounds. Because of its compactness, it can readily be transported or stored.

To operate, the current is turned on and the arc struck by touching the bottom of the crucible with the carbon. The height of the carbon and consequently the length of the arc can be regulated by raising or lowering the burette clamp. A pair of special steel worker's blue glasses should be worn by the operator at all times. A piece of thick asbestos board pierced for the carbon may be placed over the top of the furnace, to cut out the glare and concentrate the heat.

Using the furnace, the writer has prepared samples of brass and aluminum bronze of excellent quality. Apparently the furnace may be used for the preparation of any of the high melting point alloys. Steel can be melted in three or four minutes and special steel alloys prepared. Its application to the preparation of steel alloys alone insured a wide usefulness in metallurgical laboratories.

For lecture demonstration purposes, it is invaluable, illustrating the principle of the arc furnace and creating at the same time heat much higher than is obtainable from any other source.

Glass may readily be manufactured in this furnace, using sodium carbonate and sand in the proper proportions. The time required is so short that the glass may be manufactured as a lecture demonstration.

As a cheap furnace, it has no equal. The total cost (minus the resistance, which may be of the water type) will be considerably under $1. Practically all the materials for its assembling will be found in the average laboratory.

A GRAM MOLECULAR VOLUME BOX

By A. H. Beebe

Highland Park, Mich., Junior College

Teachers of chemistry find at times that high school students have difficulty in grasping the subjects of Gram Molecular Volume and Gram Molecular Weight. Various texts have taken steps to clarify the situation by supplementing the description

with small sketches of the Gram Molecular Volume. We have found that many of the difficulties of the student which result from his attempts to *imagine* a Gram Molecular Volume may be eliminated by the use of a life size G. M. V.

The one we are using is simply a cubical box made in the manual training department in conformity with specifications furnished by the chemistry classes. The work should preferably be done by chemistry students. The wood used should be one-quarter or three-eighths inch stock, well sandpapered. The inside dimensions were, of course, found by obtaining the cube root of 22,400 cubic centimeters, or very nearly 28.2 centimeters on a side. The box, were it gas tight, will then hold exactly 22.4 liters.

With an ordinary rubber stamping set having letters about one inch in height, the sides of the box were labeled as shown below. On side (1), Oxygen, the standard of molecular weights, was placed first and in red. The remainder of the lettering is in black ink. An application of a coat of white shellac followed by one of varnish produced a permanent and useful piece of lecture table apparatus.

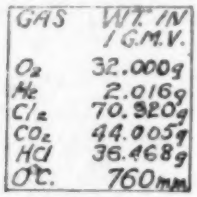


FIG. 1

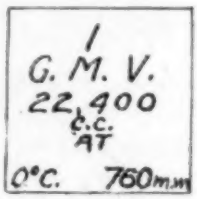


FIG. 2

FIG. 3

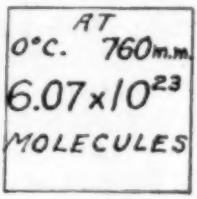


FIG. 4

Side 4 is used in Junior College chemistry to show roughly the relationship of the G. M. V. to the generally accepted results of Professor R. A. Millikan in his determination of the number of individual molecules in the gram molecular volume of a gas.

EXPERIMENTS WITH VIBRATING STRINGS AND RODS

By N. F. Smith

The Military College of South Carolina, Charleston, S. C.

An experiment which is a source of much difficulty to the average student is the familiar one on the laws of vibrating strings, in which the frequency of the string is adjusted to unison with each of a set of standard forks. A very large proportion of students in physics have so poor an appreciation of pitch that the experiment for them is largely a matter of guess-work. In striving to meet the difficulty experienced by such students, the writer hit upon the following method which in its simplicity and accuracy leaves little to be desired, and entirely eliminates the use of the ear.

A suitable tension is produced in a sonometer wire, provided with a movable fret for varying the length of the vibrating part. A standard tuning fork is struck and held lightly against the wire, close to one end, so that the wire touches one prong of the fork near its middle, and a short distance away from the nodal point in the vibrating prong. The movable fret is adjusted till the wire, when vibrating in one segment, is in unison with the fork. When this condition is reached, and not till then, the wire is thrown into vigorous vibration. A sheet of white paper placed beneath the wire renders the vibrations clearly visible. Two conditions aid the student in making this adjustment with accuracy. As the wire approaches unison with the fork, variations in the amplitude due to beats are clearly discerned, which grow slower and disappear as unison is reached. If the fret is mounted on a resonating box, a clear musical note is emitted from the box when unison is attained.

The experiment may now be extended, with an increase of accuracy and added interest, by increasing the effective length of the wire until it is seen vibrating in two segments. Settings may also be made for lengths giving three and four or more segments, if the length of the wire will permit. These settings can be made with greater accuracy than the first one, since the nodal points are very sharply marked, and are disturbed by small changes in length.

It is obvious that the laws of length, tension and mass may all be studied and verified by this method.

Another experiment to which the method was successfully applied is the one in which the relative velocity of sound is determined in two metals, e. g. brass and steel. A brass and

a steel rod about 5/8″ in diameter and of equal length, about two meters, each, are provided. One of these rods is clamped at its middle point, and a stretched sonometer wire is placed at right angles to the rod so that one end of the rod just touches the wire close to one of its ends. The other end of the rod is stroked lightly with a rosined piece of leather, setting up longitudinal vibrations in the rod. The length of the sonometer wire is adjusted, as in the previous experiment, until the wire is in unison with the rod, vibrating first in one, then in two and three or more segments. Thus the average length of one segment of the wire is determined. The same process is repeated with the other rod, and the length of one segment of the wire again determined. Since the wave-length of sound in the brass and steel rods is the same, the velocities in these media are proportional to their frequencies of vibration, and these in turn are inversely proportional to the lengths of sonometer wire which give unison.

The following data taken recently in the laboratory by two students without experience will illustrate the accuracy of the method:

OBSERVATIONS WITH STEEL ROD

Length of sonometer wire	No. of segments	Length of one segment	Average length of one segment
30.2 cm	2	15.10	
45.4	3	15.13	15.08
60.1	4	15.05	

OBSERVATIONS WITH BRASS ROD

42.9	2	21.45	
64.4	3	21.47	21.46

$$\frac{\text{Velocity of sound in steel}}{\text{Velocity of sound in brass}} = \frac{21.46}{15.08} = 1.423$$

VALUES FROM SMITHSONIAN TABLES

Velocity of sound in steel, 4990 meters per sec.
Velocity of sound in brass, 3500 meters per sec.

$$\frac{4990}{3500} = 1.423$$

Of course the agreement in this case is more or less accidental, since the velocity in both brass and steel depends upon the elastic constants of the particular specimens used.

PROBLEM DEPARTMENT

Conducted by J. A. Nyberg

Hyde Park High School, Chicago

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1039 E. Marquette Road, Chicago.

SOLUTION OF PROBLEMS

754. *Proposed by Smith D. Turner, Andover, Mass.*

Given $\triangle$ ABC and a point P outside the triangle. Required to draw a line through P bisecting the triangle.

This problem was solved last month but the following solution is much simpler.

Solution by J. T. Crawford, Ontario College of Education, Toronto, Canada.

Draw a line AQ making $\angle$ CAQ = $\angle$ PAB, and making AQ a fourth proportional to AP, AB, and $\frac{1}{2}$AC. On PQ describe a segment of a circle (toward B) containing an angle equal to the supplement of $\angle$ BAQ. Let the circle cut AC at R. Then PR will bisect $\triangle$ ABC.

Proof. Let S be the point of intersection of PR with AB. Since $\angle$ SRQ is the supplement of $\angle$ SAQ, by construction, the points AQRS are concyclic and $\angle$ AQR = $\angle$ ASP. Then $\triangle$ AQR is similar to $\triangle$ APS and AP $\times$ AQ = AS$\times$AR. But AP$\times$AQ = $\frac{1}{2}$ AC$\times$AB by construction and hence AS$\times$AR = $\frac{1}{2}$ AC$\times$AB. Hence $\triangle$ ASR = $\frac{1}{2}$ $\triangle$ ABC since they have a common angle at A.

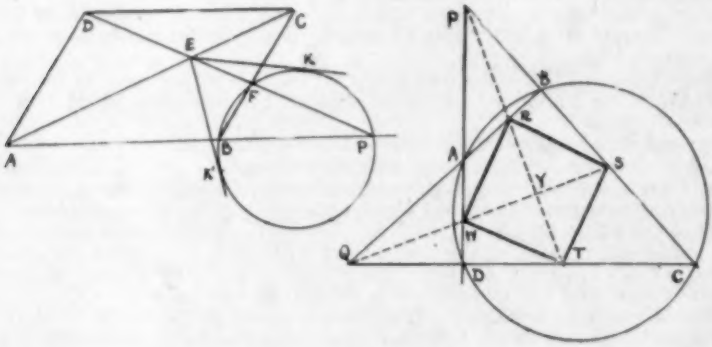
756. *Proposed by Nelson L. Roray, Metuchen, N. J.*

The side AB of the parallelogram ABCD is produced to P. The line DP intersects AC at E and BC at F. A circle is drawn through B, F, P, and from a tangent EK to this circle. Prove that the perpendicular bisector of DK passes through E.

Solution by John L. Blair, Assumption, Ill.

Since EP is a secant and EK a tangent, EK^2 = EF$\times$EP; since $\triangle$s DEC and AEP are similar, EP/DE = AE/EC; since $\triangle$s ECF and DEA are similar, DE/EF = AE/EC. From the last two proportions we find EP/DE = DE/EF or DE^2 = EF$\times$EP. Hence DE^2 = EK^2 or DE = EK. Therefore E lies on the perpendicular bisector of DK.

We may also add that the perpendicular bisector of DK′ passes through E.



Also solved by *F. A. Cadwell, St. Paul, Minn.; J. F. Howard, San Antonio, Tex.; H. Lazott, Worcester, Mass.; Asa Shannon, New Albany, Miss.; A. S. Wiener, Ithaca, N. Y.*

757. *Proposed by L. R. Kellam, Culver Military Academy, Culver, Ind.*

ABCD is a concyclic quadrilateral, where ABCD are taken in order. BA and CD intersect in Q; DA and CB in P. The bisector of $\angle P$ meets AB in R and CD in T; the bisector of $\angle Q$ meets BC in S and DA in W. Problem 744 proves that RSTW is a rhombus. What further condition imposed on ABCD will make RSTW a square?

Solution by Thomas E. N. Eaton, Redlands High School, Calif.

If we define a *kite* as a quadrilateral with two adjacent sides equal, and the other two sides equal, then the answer may be stated: If the inscribed quadrilateral is a kite, the rhombus RSTW will be a square.

If AB = AD and BC = CD, then the figure is symmetric with respect to AC. Hence RY = YW, and if the semi-diagonals of a rhombus are equal, the rhombus is in fact a square.

Also solved by *John L. Blair.*

758. *Proposed by Daniel Kreth, Wellman, Iowa.*

Show that $1+2x^4$ is never less than x^3+2x^2.

I. *Solution by R. T. McGregor, Elk Grove, Calif.*

The quantity $1+2x^4-x^2-2x^3$ may be written as $(1-x)\ (1+x-2x^2)$, which equals zero when $x = 1$. If $x<1$, let $x = a/b$, where $a<b$. Then

$$(1-x)\ (1+x-2x^3) = (1-a/b)\ (b^3+b^2a - 2a^2)\ /b^3.$$

and the factors in the right member are positive since $b>a$.

In a similar manner it may be shown that if a/b is an improper fraction, then both factors in the right member are negative and the expression is positive as before. Hence, $1+2x^4-x^2-2x^3>0$ except for $x=1$.

I. *Solution by J. F. Howard, Brackenridge H. S., San Antonio, Tex.*

The quantity $2x^4-2x^3-x^2+1$ equals $(x-1)^2[x^2+(x+1)^2]$. Since the terms in the right member are squares, the quantity can not be negative.

Also solved by *John L. Blair; F. A. Cadwell* (2 solutions); *Thomas E. N. Eaton; Michael Goldberg, Philadelphia, Pa.; James Singer, Cornell University*, '26; *A. S. Wiener* found the roots of the equation and examined the value of the function between these critical values of x; H. Lazott used the derivatives of the function to show that its minimum values occur at $x = -\frac{1}{4}$ and $x = 1$, and that for these values of x the function is not negative.

759. Anonymous.

A tells the truth 3 times out of 4; B tells the truth 2 times out of 3; C tells the truth 4 times out of 5. C makes an assertion and A and B deny it. What is the probability of the assertion being true?

Solution by J. F. Howard.

The chance of the assertion being true when A denies it is 1/4, when B denies it is 1/3, when C asserts it is 4/5. Since the reports of A, B, and C are independent of each other, the chance of the assertion being true is the product of these chances or 4/60.

The chance of the assertion *not* being true when A denies it is 3/4, when B denies it is 2/3, when C asserts it is 1/5; the product of these chances is 6/60.

The chance of the statement being either true or not true is the sum 4/60+6/60 or 10/60; hence the chance of the assertion being true is 4/60 : 10/60 or 2 : 5.

Several incorrect solutions received. For example:

Let C be replaced by D who tells the truth once out of 5 times and who affirms A's and B's statements instead of denying it as C does. Then, on the supposition that the statement is true, the probability of A, B and D affirming it is $3/4\times2/3\times1/5 = 6/60$. On the supposition that the statement is false, the probability of A, B, and D denying the statement is $1/4\times1/3\times4/5 = 4/60$. Hence the odds are 6 to 4 that the statement is true, and the probability is 6 to (6+4) or 3 : 5.

The editor does not believe the above solution is correct; if C may be replaced by D, let us see if we get the same results by replacing A by

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OIL AND GAS FIELDS OF THE UNITED STATES

A large map of the oil and gas fields of the United States has just been published by the U. S. Geological Survey, Department of the Interior. This map, which is on a scale of 40 miles to the inch, shows the oil fields in green, the gas fields in red, and the oil pipe lines and refineries in purple. These features are superimposed on a base map printed in gray, which does not obscure the oil and gas data. The map is not a revision of the last edition of the Geological Survey's oil and gas map of the United States, which was published in 1917, but is a new compilation, In its preparation the best information available to the Survey was utilized, and the proof was revised by incorporating the latest information received from officials of oil, gas, and pipe-line companies operating in all the producing states. The map measures 49 by 76 inches and is sold for $1 a copy by the Director of the U. S. Geological Survey, Washington, D. C.

A′ who tells the truth once out of 4 times, and replacing B by B′ who tells the truth once out of 3 times, and then retaining C so that A′, B′ and C all assert the statement. The probability, figured as above, will now be 2 : 5. But there is still another fallacy above: On the supposition that the statement is false, the probability of A, B and D denying it is not $1/4\times1/3\times4/5$ but $3/4\times2/3\times1/5$, because the chances that they will deny an untrue statement must be the same as the probabilities that they will affirm a true statement.

760. *For high school students.*

Solve for x and y the pair of equations:

$$(1)\quad y^2-4y+x=0;\quad (2)\quad x^2-x-2y=0$$

I. *Solution by Justine Spradling, White Plains H. S., New York.*

Subtracting (2) from (1): $y^2-x^2-2y+2x=0$, or $(y-x)\ (y+x-2)=0$.

If $y-x=0$, or $y=x$, then in (2): $x^2-3x=0$; or $x=0, 3$. The corresponding values of y are 0, 3.

If $y+x-2=0$, then in (1): $x^2+x-4=0$, or $x=(-1+\pm\sqrt{17})/2$ and the corresponding values of y are $(5\pm\sqrt{17})/2$. The solutions are $[x=0, y=0]$, $[x=3, y=3]$, $[x=(-1+\sqrt{17})/2, y=(5-\sqrt{17})/2]$, $[x=(-1-\sqrt{17})/2, y=(5+\sqrt{17})/2]$. The checks of these solutions are then shown.

II. *Solution by Charles S. Jones, Northeast H. S., Kansas City, Mo.*

From (1): $x=4y-y^2$. Substituting this value of x in (2), the result can be written $y\ (y-3)\ (y^2-5y+2)=0$. Hence $y=0, 3, (5\pm\sqrt{17})/2$. The corresponding values of x are then found and the solutions checked.

The solutions of the pupils have of course been much abbreviated above. The solutions of *Howard E. Wahbert, Dickinson H. S., Jersey City* and *Edward M. Lewis, Redlands, Calif.*, were very good, but no checks of the answers were made. The next best solutions were *Aileen Clinch, White Plains, N. Y.; John McAllister, New Albany, Miss.; Pauline Mulinix, Gypsum, Colo.; Warren Oliver, Lewis and Clark H. S.; Spokane, Wash.; Virginia Owen, New Albany, Miss.*

PROBLEMS FOR SOLUTION

771. *Proposed by L. E. Lunn, Heron Lake, Minnesota.*

Find the greatest numerical factor of $x(x^{12}-1)$ for positive integral values of x greater than 1.

772. *Proposed by Thomas F. Frewen, Detroit, Mich.*

From any point, P, on the circumference of a given circle an arc is described within the circle. Find the radius of this arc if it cuts off one half the area of the circle.

773. *Proposed by Harris F. MacNeish, College of the City of New York.*

Considering a pair of opposite faces of a regular dodecahedron as its upper and lower bases, find without using trigonometry the area of the middle section in terms of the edge e.

774. *Proposed by Michael Goldberg, Philadelphia, Pa.*

A point P is within a regular tetrahedron and its distances from the vertices are 3, 4, 5, 6 ft. Find the volume of the tetrahedron.

775. *For high school students. Proposed by John E. Baade, Waco, Tex.*

If $a/b = b/c = c/d$ prove that

$abc+bcd = (b+c)\ (b^2+c^2-ad)$.

Solutions of problems 756, 758, 760 have been received without the name of the solver.

Problem 773 above asks for a solution "without using trigonometry." Some of the readers have asked how soon we may expect the department to go to the other extreme and ask for solutions "using as much trigonometry as possible." The editor suggests as possible problems which he would like to have the readers discuss: 1. Which of the theorems in our geometry texts can be proved more easily by trigonometry than by our present methods? 2. Is there sufficient time in the ninth grade to teach numerical trigonometry, as the College Entrance Board recommends and also teach the algebra required by the College Entrance Board.

ARTICLES IN CURRENT PERIODICALS

American Botanist, for November, *Joilet, Ill.*, $1.50 *per year*, 40 *cents a copy*. "Flowering Plants in Maner," R. M. Crocket; "Plant Names and Their Meanings," Willard N. Clute; "Botany for Beginners," Willard N. Clute; "Important Movements of Plants," John J. Birch.

American Journal of Botany, for November, *Brooklyn Botanic Garden*, $6.00 *per year*, 75 *cents a copy*. "The Structure of the Starch Grain," O. L. Sponsler; "A Study of the White Heart-rot of Locust, Caused by Trametes Robiniophila, C. H. Kauffman and H. M. Kerber; "The Origin and Development of Lamellae in Agaricus Campestris and in Certain Species of Coprinus," Michael Levine.

American Mathematical Monthly, for June-July, *Lancaster, Pa.*, $4.00 *per year*, 45 *cents a copy*. Complete list of officers, committees and members, By-Laws and Constitution.

Education, for November, *Boston, Mass.*, $4.00 *per year*, 40 *cents a copy*. "Elementary Industrial Arts," Leon Winslow; "The Need for Techniques of School Discipline," Stephen G. Rich; "Some Observations on Vocational Guidance," Margaret Ellis; "Present Status of Guidance Activities in Junior High Schools."

Journal of Geography, for November, 2249 *Calumet Ave., Chicago*, $2.00 *per year*, 25 *cents a copy*. "Geography and World Power," James Fairgrieve; "The Development of the American Rice Industry," Arthur E. Albrecht; "A Sixth Grade Project in Geography," Mary V. Smith; "Laboratory Work in Geography," Flemin W. Cox; "Geographic Lantern Slides of Benzinger, Stuttgart, Germany," Homer P. Little.

Photo-Era, for November, *Boston, Mass.*, $2.50 *per year*, 25 *cents a copy*. "The Tale of a Portrait-Lens," August Krug; "I Accept the Challenge," Lehman Wendell; "Some Easy Lessons in Composltion," William S. Davis; "A Photographic Exposure-Record," Henry J. Sihler; "A Simple Enlarging and Copying Easel," A. D. DuBois; "Glue-Printing —a New Positive Process," Prof. O. Mente; "A Help to Amateur Pictorialists," F. Birbeck Farmer; "How to Make Adverising Sell Photographs," Studio-Light; "The Amateur Copyist," Bertha Scott.

Popular Astronomy, for November, *Northfield, Minn.*, $4.00 *per year*. "The Atmosphere of Venus," with plates xxxi-xxxiii, Alfred Rordame; "Theories on the Nature of Meteor Trains," with a note on Professor Trowbridge's Contributions to Our Knowledge of Meteor Trains,' Mabel Weil; "Twenty-eighth Meeting of the American Astronomical Society," continued; "Observations of Meteor Showers in 1922," Robert M. Dole.

School Review for December, University of Chicago Press, $2.50 *per year*, 30 *cents a copy*. "Student Participation in School Administration," J. Kenneth Satchell; "The Supervision of Instruction," Franklin W. Johnson; "Opportunities in Junior High School Work," Marion Lovis; "The Social Sciecne in the Junior High School," Seymour I. Stone; "More from Our Textbooks," Francis D. Curtis.

Scientific Monthly, for December, *Garrison, N. Y.*, $5.00 *per year*, 50 *a copy*. "The Vegetation of Australia and New Zealand," D. H. Campbell; "Easy Group Theory," G. A. Miller; "The History of the Calorie in Nutrition," Dr. Mildred R. Ziegler; "Social Life Among the Insects," William M. Wheeler; "The Marine Fisheries, the State and the Biologist, William F. Thompson; "De Anopluris," Professor G. F. Ferris; "Typographical Maps of the United States," William M. Davis; "What Next in Immigration Legislation," Robert DeC. Ward; "A Modern Mecca," A. E. Kennelly.

If you are interested in the betterment of country schools write to the United States Bureau of Education, Washington, D. C., and receive without cost, copies of bulletins, leaflets and circulars pertaining to rural education.

SCIENCE QUESTIONS

Conducted by Franklin T. Jones

The White Motor Company, Cleveland, Ohio

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E. Cleveland, Ohio.

The Editor will receive examination papers with many thanks. School examinations of all sorts are desired. Please send them in—likewise any newspaper clippings similar to the question proposed in this issue.

ACKNOWLEDGMENT

Information interesting and valuable to teachers of science and mathematics has been received from *The Sorbonne, University of Paris, France,* and *The James Watt Engineering Laboratories, Glasgow, Scotland.*

Portions of this information will be published from time to time in the department of "Science Questions" of SCHOOL SCIENCE AND MATHEMATICS.

The thanks of the Editor and readers is gratefully tendered for all such assistance.

SCIENCE TEACHERS—ATTENTION

In the October, 1922, number of SCHOOL SCIENCE AND MATHEMATICS appeared an article by Prof. Arthur J. Foley, Indiana University, Bloomington, Ind., entitled "The College Students' Knowledge of High School Physics."

This article brings sharply to our attention a condition in science teaching (not physics teaching alone) which is worthy of thoughtful consideration.

The Editor of this department believes that some (it is hoped, many) teachers would like to offer different explanations than those given by Prof. Foley and his colleagues. Also, they may be able to propose a remedy. In order to afford such an opportunity, the following questions are proposed. Suggest other questions and answer them, or ask an answer.

The list of questions asked by Prof. Foley and his colleagues is given below. 851 college students were tested, attaining an average of 19.7%.

TEST QUESTIONS IN PHYSICS

By Arthur J. Foley

1. What is the resulting volume of 1,000 cubic cm. of gas at a barometric pressure of 1 atmosphere (76 cm. of mercury) be subjected to an additional pressure of 4 cm. of mercury?
2. Taking the coefficient of expansion of steel at .000011, find the total length of an iron bridge at 20° C. if its length at 0° C. is 100 feet.
3. What is meant by the statement that the specific heat of iron is .113?
4. A 2-candle power lamp is placed 1.5 meters from a screen. Where must an 8-candle power lamp be placed to produce the same illumination on the screen?
5. What is the apparent color of a pure red (monochromatic) object when viewed in pure (monochromatic) blue light?
6. What is meant by the statement that a lens has a focal length of eight inches?
7. What causes the refraction of a beam of light when it passes from one medium to another?
8. What current will flow when the terminals of a 1-volt cell having an internal resistance of 2 ohms are connected through a resistance of 5 ohms?
9. What current is required to operate a 40 watt 110 volt incandescent lamp?
10. What principle is illustrated when a dynamo is generating a current? In other words, how does the dynamo generate an electromotive force?

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THE KABLEGRAM, which is a fun-loving fraternal review, publishes a page of funny stories for speakers each month. It has other interesting features for fraternalists. Send 50 cents for a year's subscription (or a dollar bill for three years) to *The Kablegram* Mt. Morris, Ill.

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401. *Questions suggested by the above.*

(*a*) Are these questions reasonable? If not, which ones are unreasonable and in what respect?

(*b*) Is question 9 a "practical" question? Does the failure to answer it show the non-success of teaching physics by *practical* applications? Why should so many pupils fail in answering this question?

(*c*) Is the low per cent attained in this examination due to failure to *memorize* definitions and principles? Should such definitions be *memorized*?

(*d*) Is the poor English illustrated by examples from students' papers in this article an indication of lax thinking? How should it be corrected?

(*e*) Is the poor showing due to poor teaching? If not, why not?

(*f*) What kind of questions should Prof. Foley have used instead of these if he wished to determine the real value of physics teaching? Propose such questions.

(*g*) What would have been the effect, if any, upon the standings of the students tested, if they had been compelled to pass an entrance examination to college? In other words, is the certificate system of entrance responsible for the situation?

(*h*) Is physics teaching in Indiana worse or better than in California, Illinois, Ohio, New York, Massachusetts and other states? Why?

(*i*) What is the remedy?

PROBLEM FOR SOLUTION

402. *Proposed by E. M. Schultheis, Chief of Drafting Room, The White Motor Co.*

A road is one mile up hill and one mile down hill. An automobile driver travels up the hill at 15 miles per hour. How fast must he travel down hill to maintain an average speed of 30 miles per hour?

SOLUTIONS AND ANSWERS

387. *From Swedish Student-Examen, April, 1921, published in January, 1922.*

In a calorimeter supplied with stirrer and thermometer (disregard radiation of calorimeter), is an electrically insulated metal spiral of 10 ohms resistance. When the thermometer registers 17° a current of .8 amperes is sent through the resistance. After 5 minutes the thermometer registers 18.1°. At this very moment 6 gm. of sal-ammoniac at 17° is added to the water. In a couple of minutes the salt is completely dissolved. Five minutes after the addition of the sal-ammoniac, the thermometer registers 18.16°. How much heat is given out or absorbed when 1 gm. of solid sal-ammoniac is dissolved in water. The specific heat of solid sal-ammoniac is .37. To raise the temperature of the solution a certain number of degrees can be considered to require the same amount of heat as if the salt remained undissolved in the pure water. 1 ampere through 1 ohm resistance develops .24 gram calories per second.

Solution by John Lundberg, Göteborg, Sweden.

Let the total water equivalent be called a grams and the unknown heat of solution x gram-calories.

Then $300\times0.24\times10(.08)^2=1.1a=0.06a+6\times0.37\times1.16\times6x$

Therefore $a=418.909$

$x=72.18$

Answer: The heat of solution is 72.2.

ERRATUM

On page 698, October, 1922, Vol. XXII, in the second book review, first line Sir William Bargg should read Sir William Bragg. It is purely a misprint.

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WOODLESS LUMBER

According to *Science Service* a board twelve feet wide and nine hundred feet long has recently been produced. This is a much larger board than could be produced from any tree that we know of. It is said to contain sufficient material to construct three five-room bungalows. This remarkable board was made from sugarcane, or rather from the refuse, of the cane after the sugar has been extracted. Sugar-cane refuse, known as bagasse, consists of the fibrous material of the plant and is very similar to the fiber from which paper is made. In making bagasse lumber the fiber is put through processes similar to those employed in making paper. The new lumber is said to be very light, waterproof and an excellent non-conductor of heat. Up to the present, refuse sugar cane has been of little use and is usually burned to get rid of it. Now that a way to use it has been found, it is expected that the cane fields of Louisiana, alone, will yield over 750,000,000 feet of this lumber annually. There are many demands for wood that the new material will not supply, but it can be used in so many ways that it seems destined to take much of the pressure from our rapidly diminishing forests

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ARMY OF 22,000,000 TO COMBAT FOREST FIRES

An army in which every school child in the country has been asked to enlist to combat the national enemy—forest fire.

Chief Forester William B. Greeley, of the Forest Service, United States Department of Agriculture, has just written the state superintendents of schools calling attention to the danger from the dry condition of the forest and woodlands and seeking to bring before the children the need of care with fire.

According to estimates made by the Forest Service, 33,000 forest fires occur annually; over 60 per cent are caused by human carelessness. Each year these fires burn over 7,500,000 acres, an area greater than Massachusetts, Connecticut, New Hampshire, and Rhode Island combined. Seventeen million dollars of our country's wealth is each year reduced to smoke and gray ashes.

"Can we not," asks Colonel Greeley in his letter, "enlist the school children of the country—there are twenty-two million of them—in an effective army to fight a national foe that ravages the land before our eyes?

"In your state, and in many others, forest fires are common in the fall. This year drought has made the danger unusually great. Already fires have dealt death and destruction widely in some regions. Your own state will not go unscathed. Rains may diminish the danger, but even with the most favorable conditions before snow flies thousands of fires will have run in the forests of the East and North.

"We give too little heed to small fires. They do a vast amount of harm. Our boys and girls should be taught this. They must be made to realize that good citizens are careful not to cause fires.

"The woods are royal playgrounds, for young and old. After school, and on holidays, our young people will have glorious times nutting, tramping, some of them hunting in the woods, and frolicking in the fallen leaves.

"The leaves are dry. Sun and wind and frost combine to cover the ground with potential tinder. It does not take long after a rain for the forest floor to become inflammable again. Then a little carelessness or thoughtlessness, and a fire is started.

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"I wish I might tell every boy and girl in the United States of the fires that I have seen, and the terrible results of forest fires when they become big, and the harm that even small fires do. I wish I might ask each one of them to promise me his or her help in keeping the forests green.

"I can not do that, but with your permission, I can perhaps do something like it. I can ask the teachers in every school in your state who learn of this appeal to let their classes know that the Forester wants the help of all school children and their individual pledge to be careful and to try to get others to be careful to prevent forest fires."

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

SEVENTY-NINTH MEETING AT HARVARD UNIVERSITY, CAMBRIDGE, MASS.

The annual meeting of the New England Association of Chemistry Teachers was held at Harvard University, on November 18, 1922. Dr. Norris F. Hall, of Harvard University addressed the association on the subject of "Isotopes."

Professor James Bryant Conant, of Harvard University, gave an address illustrated by lecture table experiments on "Organic Chemistry in Everyday Life."

At the annual business meeting, the following officers were elected for 1923: S. Walter Hoyt, President, Mechanics Arts High School, Boston, Mass.; J. Herbert Ward, Vice-President, Classical High School, Providence, R. I.; Alfred R. Lincoln, Secretary, Technical High School, Springfield, Mass.; Alfred M. Butler, Treasurer, High School of Practical Arts, Boston, Mass.; Lawrence R. Atwood, Assistant Secretary, Malden High School., Malden, Mass.

Division Chairmen: Gorham W. Harris, Central Division, Simmons College, Boston, Mass.; Leslie O. Johnson, Western Division, New Haven High School, New Haven, Conn.; Herbert F. Davison, Southern Division, Brown University, Providence,R. I.; Raymond R. Thompson, Northern Division, Hebron Academy, Hebron, Me.

EIGHTIETH MEETING AT PUBLIC HIGH SCHOOL, HARTFORD, CONN.

At the eightieth meeting in Hartford on December 9 the following excellent program was enjoyed. This meeting was the fourth regional meeting of the Western Division and the program was arranged by Miss Alice J. Kennedy, of the Windsor High School, Professor Charles Ruglas Hoover, of Wesleyan University, and Miss Clara A. Pease, of the Hartford Public High School, a committee serving under the direction of Division Chairman Leslie O. Johnson, of the New Haven High School.

PROGRAM.

Radio Concert. Broadcast by Hartford Courant by request.

"Working of the Audion Tube," Mr. F. H. Schnell, President, Radio Club of Hartford, Connecticut, and Traffic Manager of the American Radio Relay League.

Discussion of Radio Receiving Sets and Importance of Individual Parts, Mr. J. F. Furey, Secretary, Radio Club of Hartford, Connecticut.

Survey of the Chemistry Teaching in Connecticut, Mr. Edmund Goodreau, Chemistry Department, High School, Ansonia, Connecticut.

"Some Elementary Concepts of Radio," Mr. K. B. Warner, Editor of Q. S. T.

Radio Concert. Broadcast from W. G. Y., Schenectady, N. Y by request.

Lunch.

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Business Meeting. a. Election of Regional Committee. b. Reports of Committees. c. Election of New Members.

"Splashes from Nature's Paint Pot," Dr. G. Albert Hill, Chemistry Department, Wesleyan University.

"A Study of Chemical Equations," Mr. Max Small, Chemistry Department, High School, New Haven, Connecticut.

Trip to the Hartford Courant Broadcasting Station.—[S. Walter Hoyt, Sec.

BOOKS RECEIVED

The Historical Survey of Algebraic Methods of Approximating the Roots of Numerical Higher Equations up to the Year 1819, by Martin A. Nordgard, Grinnell, Iowa. Pages VI+64. 15½x23½cms. Cloth. 1922. Teachers College, Columbia University, New York City.

Easy Experiments in Elementary Science, by Herbert McKay. 12½ x18cm. Paper. 1922. 50 cents. Oxford University Press, London, England.

The Invertebrate Course in the Marine Biological Laboratory, by W. C. Allee. 31 pages. 18x25cm. Paper. 1922. Biological Bulletin.

The Study of Living Things, by W. H. D. Meier, State Normal School, Framingham, Mass. 96 pages plus. 20x25cm. Paper. 1922. 80 cents. Ginn and Company.

Surveys of the Department of Instruction, Cleveland Public Schools. 30 pages. 15x23. Paper. 1922. 50 cents. Cleveland Public Schools.

Junior High School Mathematics, Cleveland Public Schools. Pages 45. 15x23cm. Paper. 1922. 50 cents. Cleveland Board of Education.

General Mathematics, Book Two, by William B. Reeve, University High School, University of Minnesota. Pages XII+446. Cloth. 1922. $1.60. Ginn and Company, Chicago.

The Editor's Handbook, Kable Brothers, Mount Morris, Ill. Pages 72. 17½x25½cm. Paper. 1922. Kable Brothers, Mount Morris, Ill.

Essentials of Modern Physics, by Charles E. Dull, South Side High School, Newark, N. J. Pages X+525. 13½x19½cm. Cloth. 1922. $1.72. Henry Holt and Company, New York City.

Education for Business, by Everett S. Lytton, University of Chicago. Pages XIV+618. Cloth. 1922. The University of Chicago Press.

The Concise Physics for Engineering Students, by John E. Hoyt, Drexel Evening School. Pages XII+385. 14x20cm. Cloth. 1922. Blakiston's Sons and Company, Philadelphia, Pa.

A course in Analytic Geometry, by Paul P. Boyd, J. Morton Davis and Elijah L. Rees, University of Kentucky. Pages X+252. 14x26.5 cm. Cloth. 1922. $2.40. D. Van Nostrand Company, New York.

Synthetic Inorganic Chemistry, by Arthur A. Blanchard and Joseph W. Phelan, Massachusetts Institute of Technology. Pages XIV+ 321. 15 5-10 x 23 5-10 cm. Cloth. 1922. $3.00. John Wiley and Sons, New York.

History of Chemistry, by Francis P. Venable, Chapel Hill, N. C. Pages VII+168. 13x19cm. Cloth. 1922. D. C. Heath and Co., New York City.

Entomology with Special Reference to Its Ecological Aspects, by Justus W. Folsom, The University of Illinois. Pages VII+502. 16x23 cm. Cloth. 1922. P. Blakiston's Son and Co., Philadelphia.

Zoology, a textbook for Universities, colleges and normal schools, by Thomas W. Galloway, American Social Hygiene Association. Fourth edition. Pages XV+558. 16x23cm. Cloth. 1922. P. Blakiston's Son and Co., Philadelphia.

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BOOK REVIEW

Smith's Intermediate Chemistry, revised and rewritten by James Kendall, Professor of Chemistry, Columbia University, and Edwin E. Slosson, Editor of Science Service, author of Creative Chemistry, etc. Pages XV+566. 3.4x14.5x20.5cm. 15 full-page illustrations and many line drawings and diagrams of apparatus, etc. Cloth. 1922. List price, $3.25. The Century Co., 353 Fourth Ave., New York.

This new edition of an excellent text book and especially Slosson's preface on "Why study chemistry? "almost make one wish he knew no chemistry in order that he might begin to study it from this most enticing text. It might be said of Slosson's style, as was once said of an even more famous writer, that he "writes like an angel" although in this case the rest of the quotation is not apropos. The first thing that strikes one's attention on opening the book is the portrait of the late Alexander Smith, the original author of the text. May he rest in peace.

To give the reader of this review a glimpse of the style of the preface let us make a brief quotation from it: "The student of astronomy never gets a chance to handle a star, or even an asteroid. But the substances that the young chemist studies are always weighable, usually tangible, generally visible and frequently smellable. The student of geology never has the opportunity to make a mastodon and all he knows of a volcano or a geyser is the picture of it. But the Freshman chemist makes oxygen the first week and if he gets through the term without making a volcano or geyser he is lucky."

Those who are familiar with the earlier edition of the book will find that much of it has been rewritten. Professor Kendall, because of his long and close association with Alexander Smith at Columbia, has been able to keep the spirit of the work up to the Smith standard. The book has of course been brought down to date, and affords much material that has heretofore been available only in the literature, or in more advanced texts. The treatment of atomic number and atomic structure for example is very good. Many glimpses of chemical side lights on the Great War are given, for example "It was shown by Mosely (a brilliant young English physicist, killed at Gallipoli) that when the elements are arranged in the order of these wave-lengths, whole numbers can be assigned to each which are inversely proportional to the wave-lengths of corresponding lines in their X-ray spectra."

The book itself will have to be in the hands of the teacher who wishes to give it serious consideration with a view to using it as a text. Its place, it would seem to the reviewer, is in those courses that are designed for the student who is taking chemistry as a part of his general training although there is ample material for a very full year's work in it for even those who are planning to make an intensive study of chemistry. F. B. W.

A Laboratory Outline of Smith's Intermediate Chemistry, by James Kendall, Professor of Chemistry, Columbia University. Revised pages IX+III +127. 1.7 by 13 by 19cm. Occasional cross section diagrams of apparatus. Cloth. 1922. $1.25. The Century Co., New York.

This manual is intended to accompany the revised edition of Alexander Smith's *Intermediate Text Book of Chemistry* which was reviewed above. It includes elementary experiments and some from the *Laboratory Outline of College Chemistry.* As many of the directions are given in full detail the manual will be usable by students who are just beginning to take up chemistry. F. B. W.

Chemistry and Its Uses, A Text Book for Secondary Schools, by William McPherson and William Edwards Henderson. First edition. Pages VIII+447. 2.2x14.5x19.3cm. 260 figures, many of them half tones. Cloth. 1922. $1.60. Ginn & Co.

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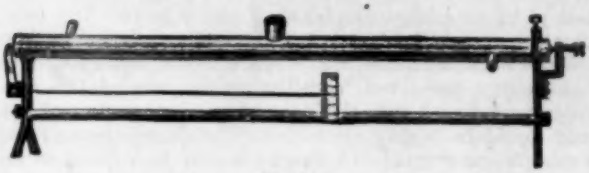

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This text attempts to make use of the appeal of the practical to induce interest on the part of the pupil. This trend is a current one, and, in the words of the authors themselves in their preface, "Just how far this tendency should be followed each author and each teacher must decide for himself; this volume represents the opinion of the present authors."

A glance at its contents shows that the more fundamental principles are attended to in somewhat condensed fashion in the first half of the book leaving the remaining space more open to practical applications. The style of the book is interesting. There is an immense amount of industrial chemistry presented, considering the size of the book, and even if it is not used as a text the possession of a number of copies for reference use would be highly desirable. The illustrations of industrial plants are exceptionally good. A short chapter on colloids is included. Every chemistry teacher should have a look at this new text. F. B. W.

College Algebra, by Walter Burton Ford, Professor of Mathematics, University of Michigan. 13x19cm. Pages vii+264. 1922. The Macmillan Company, New York.

A review of high school Algebra is given in the first four chapters, two of which are devoted to a complete treatment of the quadratic equation. Some of the usual topics of college algebra are omitted—complex numbers, partial fractions, limits, and infinite series. The problems are short, and are chosen to illustrate pointedly the mathematical principle involved. The aim throughout the book is to train the student in accuracy and conciseness of thought and expression. The chapters have been made quite independent of each other to permit adjustment of the book to either a long course or a short one. An excellent table of powers and roots closes the volume. H. E. C.

Junior High School Mathematics, Third Book, by E. H. Taylor, Ph. D., Instructor in Mathematics, and Fiske Allen, A. M., Principal of the Training School, Eastern Illinois State Normal School. 13x19cm. Pages x+149. 1922. Henry Holt and Company, New York.

The distinct aim of this book is to make algebra mean something before giving the technique of its symbols. The course in algebra in the three books of the series satisfies the requirements of admission to most colleges. As it is begun very simply in the seventh year in close connection with arithmetic and continued throughout the eight and first half of the ninth year, it should give a much better preparation for further study of mathematics than a single year of Algebra in the ninth year. The third book stresses formulas, showing how they are made up for practical purposes and how they are used in solving problems. Near the close of the book is a chapter on graphs.

H. E. C.

Elements of Projective Geometry, by George Herbert Ling, George Wentworth, and David Eugene Smith. 14 x 21 cm. Pages VI + 186. 1922. Price, $2.80. Ginn and Company, Boston.

This introductory course is planned to be of value not only to students who are to continue work in higher mathematics and to engineers, but also to prospective teachers of secondary-school mathematics. There is no doubt but what the teacher of high school mathematics can do much better work with a thorough training in subject matter; this course in projective geometry, emphasizing its application to the geometry of the high school, will give the teacher a new and clearer notion of Euclidean geometry. The theorems are clearly stated, the diagrams are carefully drawn, and the exercises are abundant and well chosen.

H. E. C.

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6	106	**206**	.....	**Africa: Sanson's projection.**
7	107	207	.....	Australasia: Mercator's projection.
9	**109**	.....	**309**	**United States of America: conic projection.**
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10	**110**	.....	.....	**United States of America: state outlines only: conic projection.**
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14	114	.....	.....	The British Isles: conic projection.
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17	117	.....	.....	France: conic projection.
18	118	.....	.....	The Spanish Peninsula: conic projection.
19	119	.....	.....	Italy: conic projection.
20	.....	.....	.....	Central Europe: conic projection.
21	121	.....	.....	The German Empire: conic projection.
24	**124**	.....	.....	**The Levant: conic projection.**
....	.....	226	.....	China and Japan: Bonne's equal-area projection.
....	132	232	.....	United States of America, by counties with names: conic projection.
....	133	.....	.....	Chicago and vicinity: conic projection.
51	**151**	.....	.....	**North Dakota: conic projection.**
				Graphs
80	.....	.....	.....	**Climatic Chart (yearly).**
....	**181**	.....	.....	**Monthly Weather Chart.**

THE UNIVERSITY OF CHICAGO PRESS, CHICAGO, ILL.

Vector Analysis, by James Byrnie Shaw, Professor of Mathematics in the University of Illinois. 14 x 20 cm. Pages V + 311. 1922. Price, $3.50. D. Van Nostrand Company, New York.

In the introduction the author gives a brief historical account of the various systems of vector calculus. Since it appears that for all purposes of the physicist and for most of those of the geometer the use of quaternions is by far the simplest in theory and in practice, he has followed this method in this text. Every physical term beyond mere elementary terms is carefully defined; then is a large collection of problems and exercises which reveal the utility of the mathematical methods. As the text takes the student gradually from the elementary to the profundities of mathematical physics, it is extremely well suited for class work.

H. E. C.

The Elements of Astronomy, by D. N. Mallik, B. A., Sc.D., F. R. S. E., Professor, Presidency College, Calcutta. 15 x 22 cm. Pages 233. 1921. The University Press, Cambridge.

The portions of astronomy which involve only elementary mathematics are treated in a very interesting way in this text. The historical introduction, from the point of view of an Indian astronomer for his students, naturally emphasizes the astronomical observations and knowledge of the early astronomers of India. The text aims to give a clear and accurate presentation of astronomical facts, principles, and methods in such form that they can be easily apprehended by the average student with a reasonable amount of effort.

H. E. C.

Elementary Manual of Physiology, by Russell Barton-Opitz, Columbia University. 411 pages. 14 x 20.5 cms. Cloth. 1922. $2.50 net. W. B. Saunders Co., Philadelphia.

This is a splendid book which has come from the press at a very opportune time. It is a book midway between that which should be used by high school students and those in the first year of the university course. And it fits the nitch that has for many years been demanding a book of this character. It surely will do much toward stimulating the study of this most important subject. It is divided into six parts, under the general heads of physiology of muscle and nerve, circulation of the blood and limp, respiration, nutrition, the nervous system, and the sense organs. The book is splendidly written, diction is almost perfect, and one with any interest in physiology cannot help but become interested in the perusal of the same. There are 40 chapters. Major paragraphs begin with bold faced type, the material in bold faced type indicating the subject matter to be treated in this particular paragraph. It is printed in ten point type on paper that is not too glossy. There are 147 drawings that have been especially selected for the text. Mechanically, the book is well made. It deserves a wide circulation among first year university and college students.

C. H. S.

Education for Business, by Leverett F. Lyon, University of Chicago. Pages XIV + 618. 14½ x 20 cm. Cloth. 1922. University of Chicago Press.

When one begins a review of such a book as this, he is at a loss to know just what to say, there are so many good things that could be said.

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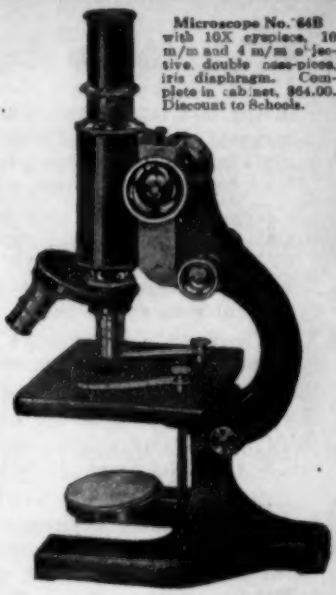

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in the last few years. The author shows a remarkable knowledge of business principles and his familiarity with different methods of conducting business, by his splendid arrangement, not only of the work in the book but in the way that it is presented.

The book will not only be used in schools of commerce and administration but is one that any active business man may read with credit to himself as he surely will secure therefrom many new ideas which, if incorporated in his business will enable him to make the business more efficient than otherwise.

There are many graphs and tables scattered throughout the book. It is an admirable presentation of business principles.

Mechanically the book is well-made.

C. H. S.

Essentials of Modern Physics, by Charles E. Dull, Newark School of Technology. Pages X + 525. 13 x 19 cm. Cloth. 1922. $1.72. Henry Holt and Company, New York City.

In the making of physics texts there is apparently no end. This most recent book, however, seems to justify its appearance by presenting to the physics world so many new things which have been developed in the last few years.

It contains 546 diagrams, many of which are absolutely new and unique although at the same time many of the old classical figures are still retained. These figures and halftones have been selected with the idea of presenting to the student very concisely the nature of the things discussed in the accompanying paragraphs. The author believes in presenting the subject in such a clear and concise way that it will cause the pupil to think, reason, and use his common sense.

There are twenty-nine chapters and several appendices in the text. The book contains much more matter than the average high school pupil can absorb in one year's work but this is not a fault of the book as a text in this subject should contain everything of an elementary nature contained in the great subject of physics. This will enable the teacher to select such parts which, in his judgment, are the most important to fit that part of the country in which the subject is being taught.

The automobile is nicely discussed in the latter part of the book. All major paragraphs have the subject to be discussed in that paragraph printed at the first in bold-faced type. The body of the work is in ten point. Each chapter closes with a list of questions discussed in that chapter.

It is written in a clear and concise style. The diction is good. Mechanically the book is well-made and will stand rough usage. There is a complete index of thirteen double-columned pages.

All physics teachers should possess themselves of a copy of this book.

C. H. S.

Easy Experiments in Elementary Science, by Herbert McKay. 144 pages. 12 x 16 cm. Paper. 1922. 50c. Oxford University Press, American Branch, 35 West Thirty-second St., New York City.

This splendid book is intended for work among younger pupils although it can be used with those who are more mature. The apparatus needed is of the most simple kind and with few exceptions all of the material may be found in the home. Most pupils with the average degree of intelligence will be able to perform these experiments without the assistance of an instructor. They are of a very interesting nature and without question will stimulate in the young mind a desire for a more extended knowledge of science.

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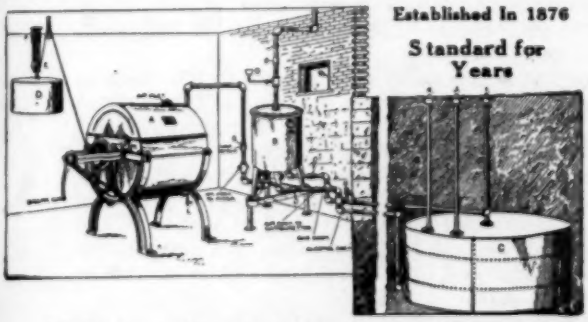

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Principles of Human Geography, by Ellsworth Huntington, Yale University, and Sumner W. Cushing, Normal School, Salem, Mass. Pages XIV + 430. 16 x 23½ cm. Cloth. 1922. $3.50. John Wiley and Sons, 432 Fourth Ave., New York City.

This really extraordinary book has many new features in the teaching of geography which no other book published contains. The method adopted in this text is first to look at the physical background, after which it bears down heavy on the human side of geography.

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The Lincoln School of Teachers College, a descriptive pamphlet edited by Dr. O. W. Caldwell. Pages IV + 80. 13½ x 20 cm. Paper. 1922. Lincoln School of Teachers College, 425 W. 123d St., New York City.

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The Expert Typist, by Clarence C. Smith, Washington, D. C., Business High School. Pages XIII + 274. 14 x 20 cm. Cloth. 1922. The Macmillan Company, New York.

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